Environment CANADA Environnement
20229931 VOL 84- ISS 14 851100
EXC # 001
TD 171.5.C3 R43
REGIONAL PROGRAM REPORT (CANADA. EN
VIRONMENTAL PROTECTION SERVICE. PAC
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Environment Canada

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Environmental Protection Service

Service de la protection de l'environnement

DEPARTMENT OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

POINT GREY OCEAN DUMP SITE ASSESSMENT REPORT, 1980-1984

Regional Program Report: 84-14

By

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November 1985

ABSTRACT

Between July 1980 and April 1984 six benthic sediment chemistry studies and three benthic fauna studies were conducted in the vicinity of the Point Grey Spoil Area in Georgia Strait, British Columbia. The studies were conducted by Environmental Protection Service, Environment Canada which administers the Ocean Dumping Control Act of Canada. The purpose of the studies was to determine trace metal accumulation in benthic sediments and fauna resulting from dumping dredge spoils and excavation material originating from the British Columbia lower mainland.

RÉSUMÉ

Entre juillet 1980 et avril 1984, six études des sédiments benthiques et trois études de la faune benthique furent entreprises à proximité de l'Aire de Déblais de Point Grey dans le détroit de Georgia, en Colombie Britannique. Les études furent entreprises par le Service de Protection de l'Environnement, Environnement Canada. Ce service administre la loi sur l'immersion des déchets en mer du Canada. Le but de ces études fut de déterminer l'accumulation des métaux traces dans les sédiments et la faune benthique, résultant des déversements dedéchets de draguage et matériaux d'excavation provenant de la partie continentale inférieure de la Colombie Britannique. Ce rapport présente les résultats de ces études.

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SUMMARY

The Point Grey Ocean Dump Site has been utilized for the disposal of wastes for many years. Since the Ocean Dumping Control Act was proclaimed in 1975 approximately 2,000,000 cubic metres of regulated dredge spoil has been deposited at the site.

The analysis of sediments during the present study period did not indicate a trend in trace metal concentrations. Occasional elevated levels, of cadmium in particular, at certain stations were not substantiated on subsequent surveys. These anomalies may be due to the heterogeneity of sediments at the dump site, changes in analytical procedures, contamination of samples after collection or a combination of these variables. It is recommended that cadmium levels at the dump site continue to be closely scrutinized and that more sensitive analytical procedures be used to reliably quantify this trace metal at low levels.

Bioaccumulation was not evident in the benthic epifauna and infauna species collected. Trace metal concentrations in these species were generally within the ranges identified previously for the coast of British Columbia.

Submersible dive observations substantiated earlier findings (Packman 1980) that more dumping had taken place in the northeast quadrant of the dump site. Qualitative observations made during the dives suggested that areas characterized by much dumped material were inhabited by reduced numbers of benthic epifauna. A decrease in burrowing activity (craters) in these areas suggested that infaunal communities may also be depressed.

1.0 INTRODUCTION

Routine monitoring and assessment of the impacts of ocean dumping activities at designated ocean dumpsites is carried out by the Environmental Protection Service (E.P.S.). This work is intended to identify large scale impacts on the marine environment or trends in the chemical composition of sediments at the dumpsite. Studies of a more detailed nature are supported by the National Ocean Dumping Control Act Research Fund and are designed to define the long-term environmental implications of disposing certain substances.

E.P.S.'s surveys conducted in July 1980, March 1982, November 1982, September 1983, November 1983, and April 1984 are reported here. Previous studies conducted in 1975/76 and 1978 are reported in Packman 1980.

The authors would like to emphasize that many improvements have been made to analytical procedures for trace metal determinations since the initial study at Point Grey (Packman 1980) and more particularly during the last couple of years. It is recommended that the data presented in this report be viewed in that context. Also for this reason, trace metal data from Packman 1980 are not presented for comparative purposes.

1.1 Study Area

The Point Grey ocean dumpsite (Figure 1) is located approximately 7.4 km west of Point Grey in the Strait of Georgia.

The designated dumpsite is delineated by a circular boundary with a 1 nautical mile (1.85 km) radius, centered at 49°15.45'N, 123°22.10'W, in the Strait of Georgia. Water depths at this site vary from 210-275 metres, with an average of approximately 250 metres. The study area extends 2 nautical miles (3.7 km) beyond the dumpsite boundary (Packman 1980) (Figure 2).

A summary of the type and quantity of material dumped at Point Grey since the institution of the Ocean Dumping Control Act is contained

in Appendix I. Estimates of total volumes disposed of at Point Grey for each year are:

1976 - 183,400 m^3	1980 - 200,350 m^3
1977 - 770,000 m^3	1981 - 240,000 m^3
1978 - 78,000 m^3	1982 - 306,600 m^3
1979 - 166,400 m^3	1983 - 150,000 m^3

Total Volume: 2,094,750 m^3

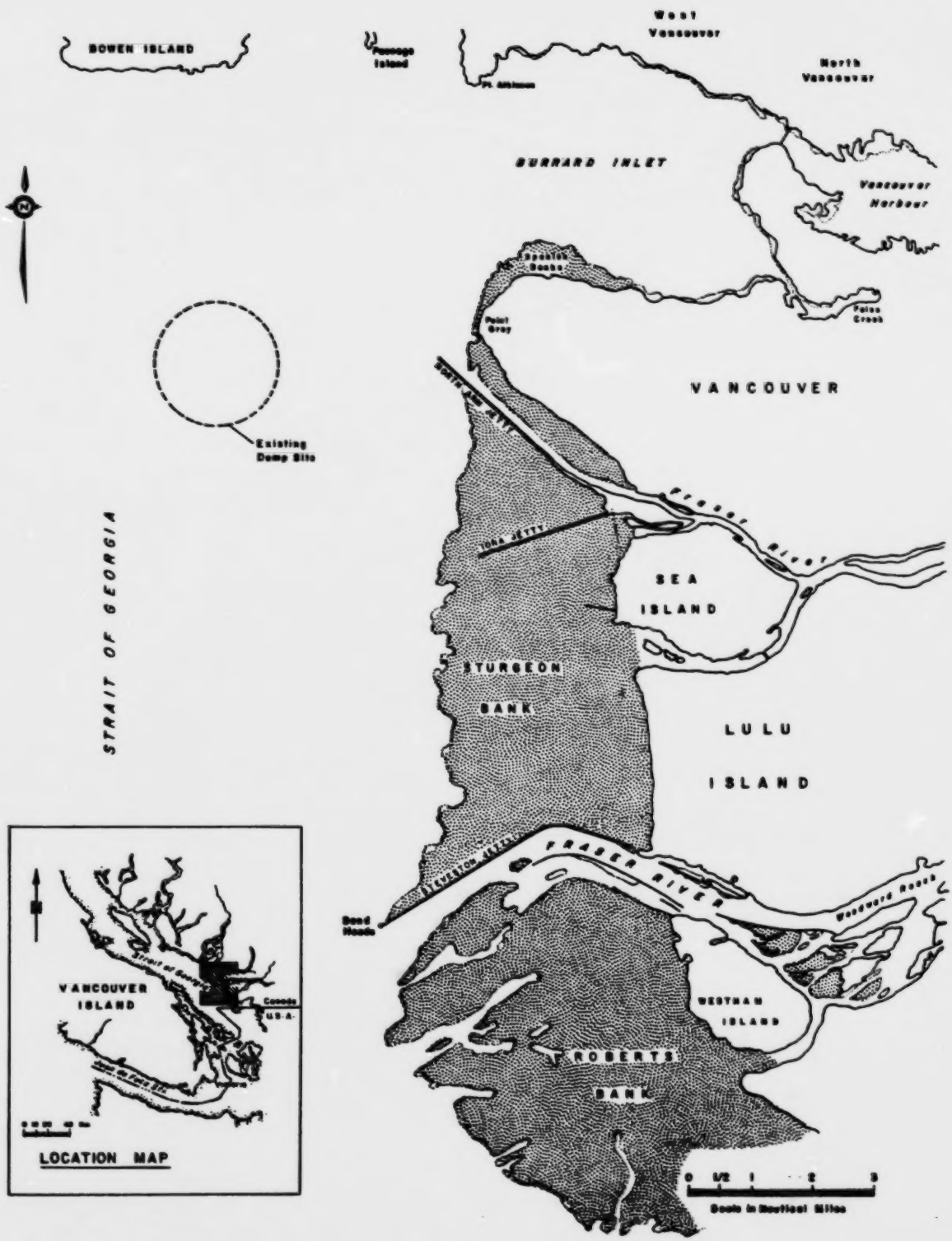

FIGURE 1 LOCATION MAP - POINT GREY OCEAN DUMPSITE

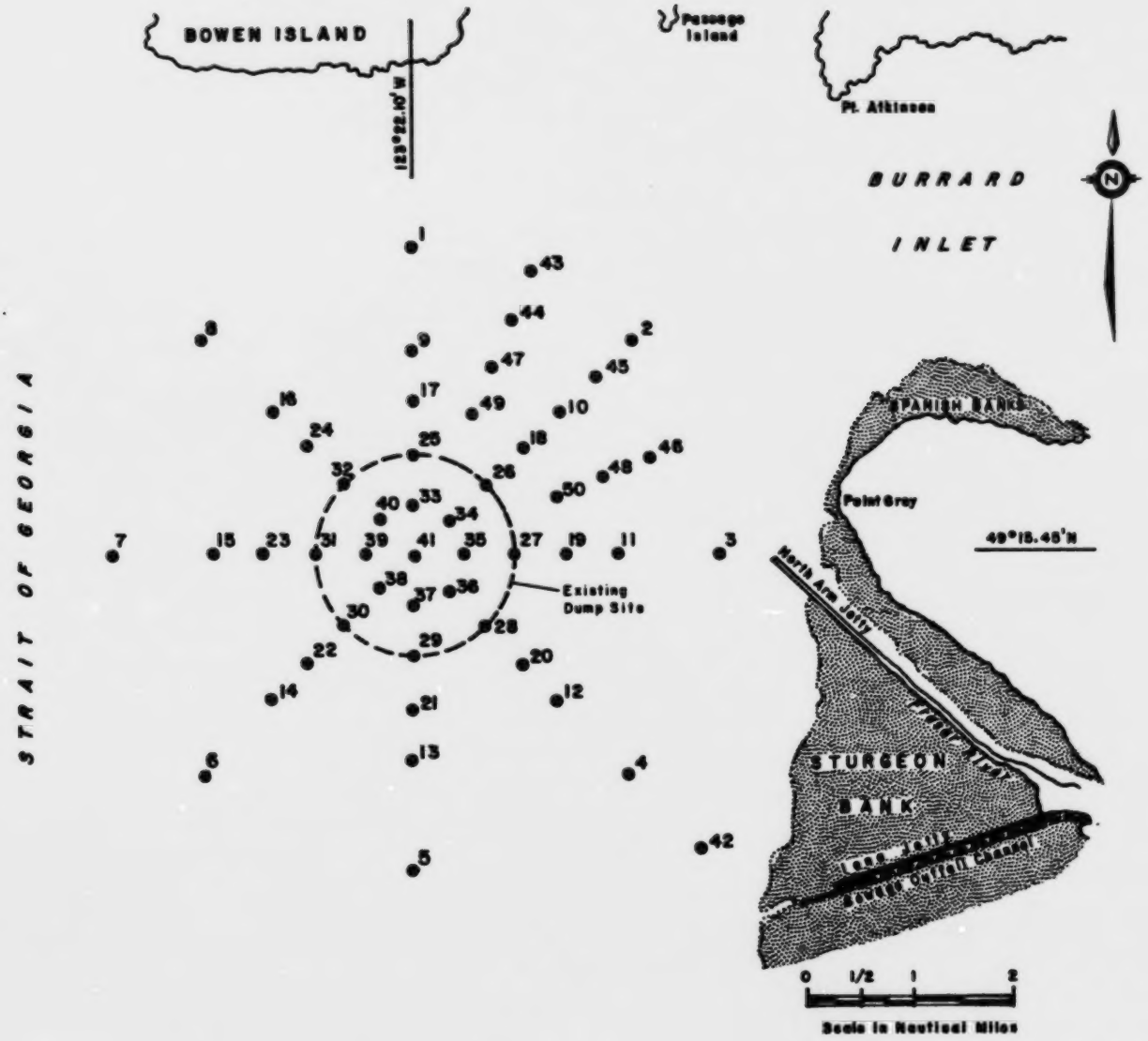

FIGURE 2 BENTHIC SEDIMENT (GRAB AND CORE) STATIONS
POINT GREY - OCEAN DUMPSITE, 1980 - 1984

2.0 METHODS AND MATERIALS

2.1 Benthic Sampling

2.1.1 Field Procedures - Core and Grab Sampling. Sediment cores were obtained in July 1980, March 1982, and April 1984 using a BENTHOS Gravity Corer. Intact cores were extruded into a plastic trough and measured. Samples were removed from selected depths (0-10 cm., 30-40 cm., and 60-70 cm.) to plastic bags and frozen prior to trace metal analysis. In all other surveys, a 0.1 m^2 SMITH McINTYRE Grab Sampler was used to sample sediments. Representative samples were removed from each grab to a plastic and/or paper bag and frozen prior to trace metal analysis.

2.1.2 Field Procedures - Benthic Trawls. Benthic trawls were conducted at selected locations at and near the Point Grey dumpsite (Figures 3 and 4). The trawling gear consisted of an otter trawl with 3.8 cm mesh body and a 5.8 metre throat. The trawl was lowered to the bottom with a 3 to 1 scope (three times the amount of wire as the depth at the trawl location) and towed on the bottom for 1.0 nautical mile. After each tow, the contents were washed, sorted and identified. Selected tissue samples were removed for trace metal analysis; the remaining animals were returned to the sea.

2.1.3 Analytical Procedures. Analytical procedures for trace metals in sediments and tissues are given in Appendix IV, IVa, & V. The analyses were performed by the Environmental Protection Service - Department of Fisheries and Oceans Laboratory Services in West Vancouver. The procedure for sediments was modified in 1983 as noted in the Appendices. Certified reference sediments were included during the analysis of sediment samples from September and November 1983, and from April, 1984. A complete heavy metal scan was conducted on each sample. Results for cadmium (Cd), mercury (Hg), lead (Pb), copper (Cu) and zinc (Zn) are tabulated.

2.1.4 PISCES IV Submersible Dives. Pisces IV submersible dives were conducted in November 1983. Dive tracks (Figure 5) were selected on the basis of results of sediment sampling and previous dive surveys. Diver observations recorded on tape and transcribed are presented in Appendix II. A photographic record of each dive was recorded on 70 mm film.

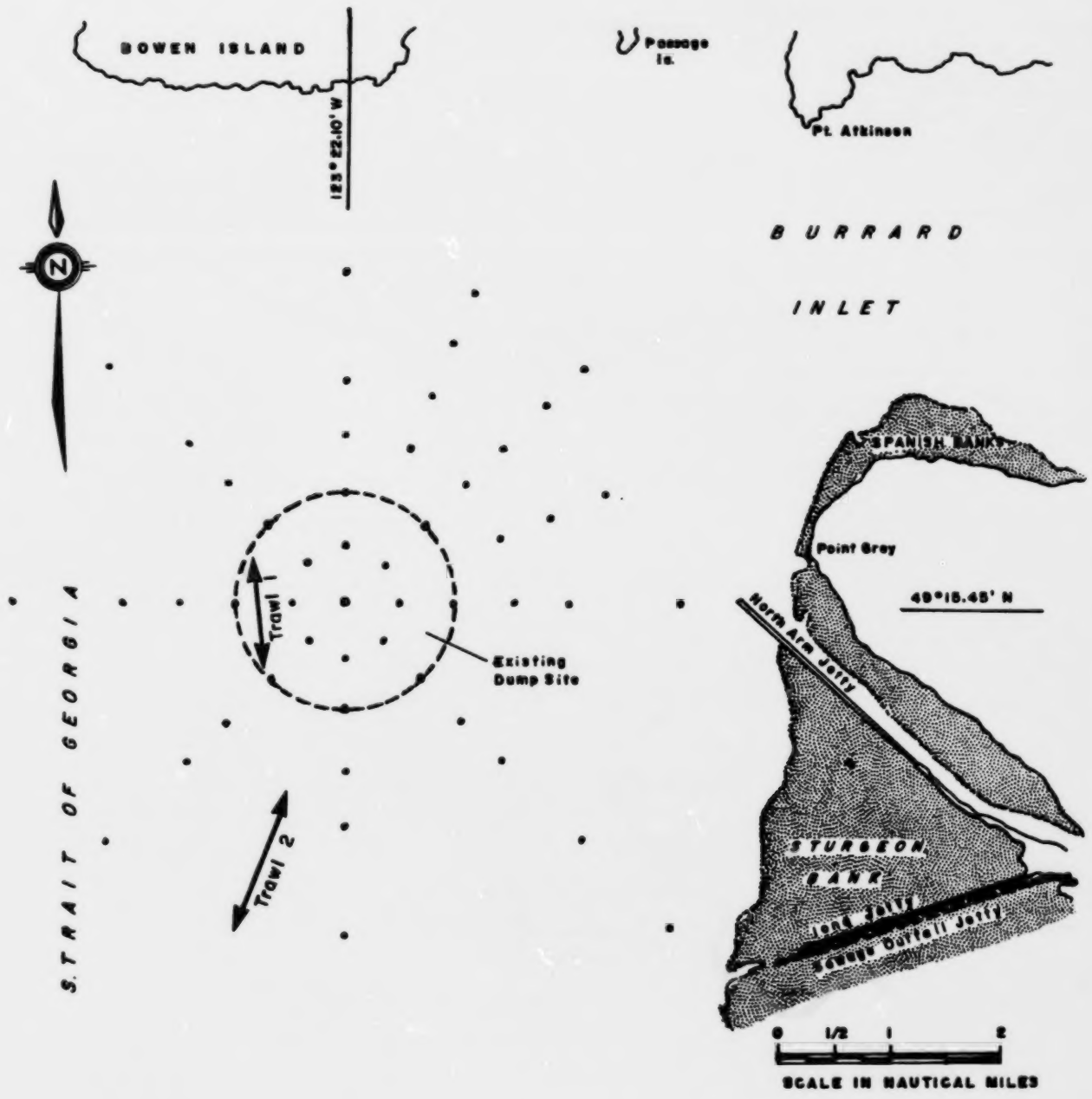

FIGURE 3 TRAWL STATIONS - POINT GREY OCEAN DUMPSITE, November 1982

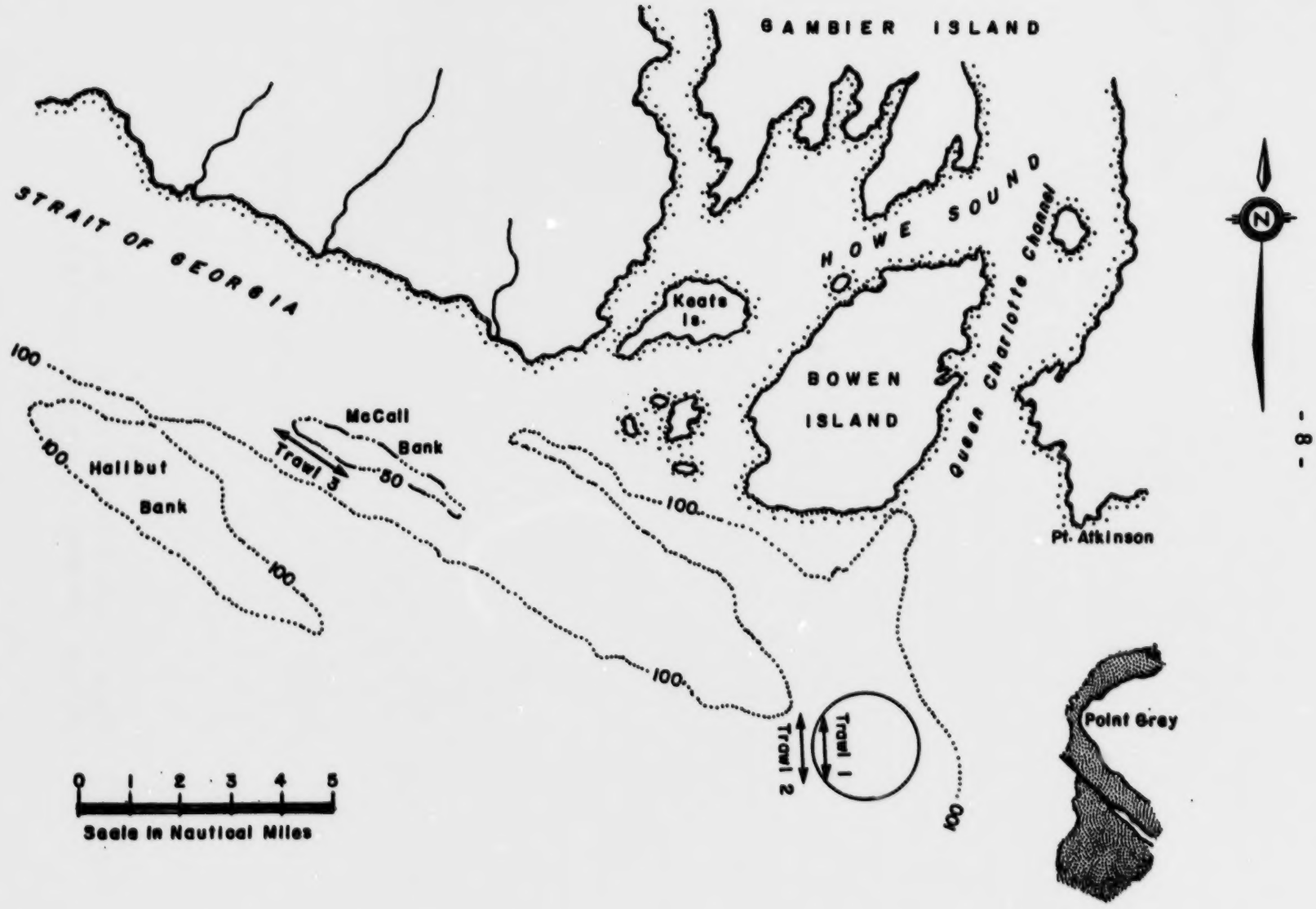

FIGURE 4 TRAWL STATIONS - POINT GREY OCEAN DUMPSITE - September, 1983

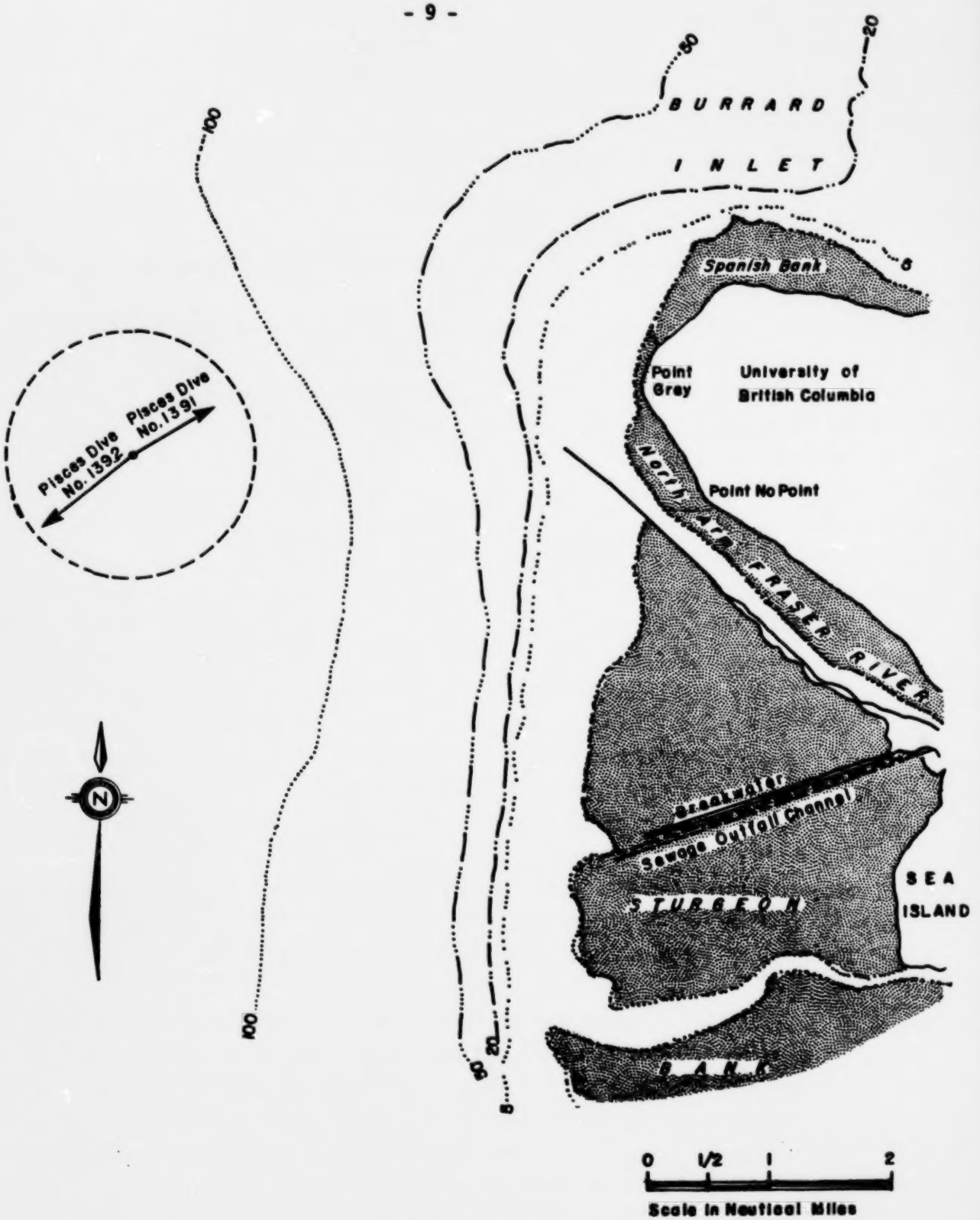

FIGURE 5 PISCES IV SUBMERSIBLE DIVE TRACKS-
POINT GREY OCEAN DUMPSITE, November 1983

3.0 RESULTS AND DISCUSSION

3.1 Trace Metals in Sediments

The trace metal analysis results are presented in Tables 1 to 6 and are expressed in ug/g, dry weight.

Trace metal concentrations in sediments did not show any trend over the study period (1980 - 1984). Data presented herein suggests that ocean dumping activities at the Point Grey dumpsite have not significantly elevated trace metal levels in the sediments. The trace metals mercury and cadmium listed in Schedule I of the Ocean Dumping Control Act (i.e: prohibited substances) are of prime concern in the marine environment. Mercury levels in sediments collected since 1980 were not detected above 0.75 mg/kg, the ODCA regulated limit. The regulated limit of 0.6 mg/kg for cadmium was exceeded in some samples; however, the results are quite variable and the analytical technique (Inductively Coupled Argon Plasma exitation source coupled to an Optical Emission Spectrophotometer, or "ICAP") cannot reliably quantify cadmium at the lower concentrations i.e.: around 0.6 mg/kg. Also, in the case of cadmium, environmental concentrations may exceed the regulated limit naturally and Canada has chosen to use the existing regulated levels as screening limits.

The September 1983 cadmium results (Table 4) have not been adjusted to reflect the poor reference sediment analysis results run for quality control purposes and should be viewed accordingly. The November 1983 samples were run in two separate lots, each with its own reference sediments as noted at the end of Table 5. These results also have not been adjusted.

Three replicate samples were collected during the September 1983 survey allowing population mean and population standard deviation to be included with this data set (Table 4). Two replicate samples collected during the November 1983 survey were analysed in duplicate or triplicate allowing sample mean and sample standard deviation to be included with this data set (Table 5). Five replicates of each of seven samples from the

April 1984 survey (Table 6) were analysed and reported in Table 7. Reference materials run with the April 1984 samples appear in Table 8. Data for the April 1984 survey which was reported by the laboratory as less than the limit of detection (L.O.D.) is reported here as not detected (N.D.) with the L.O.D. appearing in brackets.

In view of the changes in laboratory procedures for cadmium during the survey period and the L.O.D. using I.C.A.P. it is difficult to interpret the cadmium results. Although there were several elevated values recorded in November 1983, it is impossible to reliably postulate any trend in cadmium levels. Further careful study for this trace metal is recommended.

3.2 Trace Metals in Benthic Invertebrates

Selected samples were removed from benthic trawls for trace metal analysis (Tables 9 and 11). Cadmium concentrations in fish muscle tissue do not appear to increase with increasing size or age. In fact, higher cadmium levels are often detected in the smaller individuals (Garrett 1984). Elevated levels of cadmium in smaller individuals were observed in the November 1982 and September 1983 benthic fauna results. Cadmium is elevated in Pandalopsis dispar and Pandalus sp. but is generally below detection limit in the fish samples.

Molpadia intermedia (sea cucumber) were collected with a Smith-McIntyre grab sampler and submitted for trace metal analysis (Table 10). One specimen (Station 49) was noted to have higher levels of lead, copper and zinc than the remainder. Cadmium and mercury levels were not elevated. Previously recorded wet weight levels of cadmium in shrimp (whole body) and crab muscle in B.C. are 0.10 to 2.7 mg/kg for shrimp and 0.01 to 0.10 mg/kg for crab (Garrett, 1984).

Mercury was found to be highest in fish and crab tissue; however, the levels were under the Health and Welfare Canada limit of 0.5 mg/kg (wet weight) for the safe human consumption of fish and shellfish. There are no existing limits for lead, copper, cadmium or zinc under Health and Welfare Canada Guidelines.

3.3 Pisces IV Dives (See Appendix II for detailed dive reports)

3.3.1 Dive Number 1391. The dive track began at the centre of the designated spoil area in approximately 245 metres and proceeded in a north easterly direction for about three quarters of a nautical mile. The bottom on the first part of the dive was flat and composed of fairly solid light brown sediment. There was much physical evidence of dumping including steel cables and bundle ties, bricks, building blocks, boom chains, clumps of sandstone and large rocks. Benthic animals observed are listed in Appendix II with brittle stars being the most numerous species. Pink and sidestripe shrimp were present as would be expected, however the numbers seemed reduced over similar areas in Georgia Strait. The marine life (ie: squat lobster, rockfish, snails, shrimp) normally associated with logs and other solid objects such as cement blocks, large rocks, etc. was also reduced. On the second half of the dive the numbers of benthic animals decreased even more. Most noticeable was the reduction in brittle star numbers and signs of burrowing activity (ie: craters, hollows, bumps). There was still much physical evidence of dumping up to the end of the dive.

3.3.2 Dive Number 1392. The dive track commenced at the centre of the designated spoil area at a depth of 245 metres and proceeded on a course of 245°T for one nautical mile (ie: to the outer perimeter of the designated spoil area). As with the previous dive (1391) there was a lot of debris from dumping such as cable, bricks, cement, pipe, bundle ties, and small clumps of rock/gravel/clay. There was more evidence of burrowing activity (ie: craters) and this increased towards the end of the dive. The animals normally associated with wood debris and other solid objects were again reduced. On the later half of the dive less dumped material was observed.

TABLES

TABLE 1 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, JULY 1980

Coordinates: 49°15.4'N, 123°22.1'W

STATION	DEPTH (cm)	Hg	Cd	Pb	Cu	Zn
1	0-10	0.156	< 0.55	82.0	59.0	116.
	30-40	< 0.127	< 0.55	74.5	47.5	102.
	60-70	0.222	< 0.55	80.5	43.5	99.5
2	0-10	0.160	< 0.55	73.5	59.0	109.
	30-40	0.196	< 0.55	67.5	50.5	97.9
	60-70	0.143	< 0.55	66.0	46.4	99.0
3	---------- NO SAMPLE ----------					
4	0-10	0.150	< 0.55	80.0	51.0	115.
	30-40	0.236	< 0.55	81.0	52.0	121.
	60-70	0.193	< 0.55	75.0	52.0	115.
5	0-10	0.193	< 0.55	76.0	44.0	105.
	30-40	0.196	< 0.55	80.0	46.7	112.
	60-70	0.160	< 0.55	74.0	44.8	102.
6	0-10	0.152	< 0.55	88.0	47.6	109.
	30-40	0.186	< 0.55	80.5	47.5	105.
	60-70	0.160	< 0.55	74.0	44.8	102.
7	0-10	0.227	< 0.55	83.4	49.6	111.
	30-40	0.180	< 0.55	83.5	48.7	105.
	60-70	0.219	< 0.55	80.0	42.6	96.5
8	0-10	0.253	< 0.55	92.5	56.5	122.
	30-40	0.148	< 0.55	87.0	50.5	103.
	60-70	0.219	< 0.55	80.0	42.6	96.5
10	0-10	0.236	< 0.55	89.0	119.0	123.
	30-40	0.242	< 0.55	67.0	47.9	106.
	60-70	0.189	< 0.55	66.5	47.1	96.0
18	0-10	0.211	< 0.55	70.0	49.3	124.
	30-40	< 0.125	< 0.55	65.5	47.5	105.
	60-70	0.158	< 0.55	62.0	46.4	97.0
25	0-10	0.207	< 0.55	88.0	47.5	167.
	30-40	0.189	< 0.55	87.0	51.0	102.
	60-70	0.152	< 0.55	81.5	46.8	95.0

*All results expressed in ug/g dry weight

Continued...

TABLE 1 **POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, JULY 1980 (Continued)**

Coordinates: 49°15.4'N, 123°22.1'W

STATION	DEPTH (cm)	Hg	Cd	Pb	Cu	Zn
26	0-10	0.154	< 0.55	68.0	48.8	106.
	30-40	0.230	< 0.55	73.5	48.9	109.
	60-70	0.154	< 0.55	63.0	45.8	99.5
27	0-10	0.177	< 0.55	57.5	46.7	100.
	30-40	0.143	< 0.55	69.0	51.0	107.
	60-70	0.193	< 0.55	67.0	46.9	105.
28	0-10	0.154	< 0.55	70.0	49.1	105.
	30-40	< 0.124	< 0.55	73.5	46.6	107.
	60-70	< 0.122	< 0.55	69.0	43.0	94.0
29	0-10	0.239	< 0.55	73.5	42.8	98.
	30-40	< 0.133	< 0.55	74.5	44.9	102.
	60-70	0.193	< 0.55	72.5	46.0	102.
30	0-10	0.158	< 0.55	80.0	48.3	110.
	30-40	0.162	< 0.55	81.0	49.0	110.
	60-70	0.141	< 0.55	69.5	44.0	97.5
31	0-10	0.239	< 0.55	83.0	54.0	124.
	30-40	0.269	< 0.55	74.0	49.8	111.
	60-70	0.160	< 0.55	72.0	47.8	100.
32	0-10	0.236	< 0.55	88.0	59.5	149.
	30-40	0.160	< 0.55	88.0	54.5	108.
	60-70	< 0.113	< 0.55	83.5	50.5	97.0
33	0-10	0.156	< 0.55	91.5	52.5	179.
	30-40	< 0.132	< 0.55	83.0	50.0	120.
	60-70	< 0.128	< 0.55	83.5	48.0	96.5
34	0-10	0.180	< 0.55	55.0	39.6	82.5
	30-40	0.154	< 0.55	65.0	42.7	110.
	60-70	0.184	< 0.55	70.5	44.9	104.
36	0-10	0.402	< 0.55	70.0	49.2	123.
	30-40	0.239	< 0.55	64.5	44.3	108.
	60-70	0.284	< 0.55	65.5	43.3	92.5

*All results expressed in ug/g dry weight

Continued...

TABLE 1 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, JULY 1980 (Continued)

Coordinates: 49°15.4'N, 123°22.1'W

STATION	DEPTH (cm)	Hg	Cd	Pb	Cu	Zn
37	0-10	0.135	< 0.55	82.5	48.7	107.
	30-40	0.154	< 0.55	80.0	47.5	106.
	60-70	0.152	< 0.55	71.5	45.6	99.0
38	0-10	0.158	< 0.55	81.0	48.8	125.
	30-40	0.198	< 0.55	78.0	47.5	122.
	60-70	0.193	< 0.55	77.5	45.0	88.0
39	0-10	0.172	< 0.55	87.5	51.5	127.
	30-40	0.156	< 0.55	75.5	47.6	111.
	60-70	0.191	< 0.55	75.5	48.3	112.
40	0-10	0.154	< 0.55	84.5	50.0	119.
	30-40	0.160	< 0.55	92.5	51.0	102.
	60-70	0.150	< 0.55	74.5	46.0	115.
43	0-10	0.162	< 0.55	75.5	58.0	114.
	30-40	0.156	< 0.55	73.0	52.0	108.
	60-70	0.158	< 0.55	74.5	47.4	94.5
44	0-10	0.133	< 0.55	82.5	51.0	92.5
	30-40	0.135	< 0.55	78.5	43.5	90.5
	60-70	0.158	< 0.55	73.0	40.5	90.5
45	0-10	0.242	< 0.55	101.0	73.5	179.
	30-40	0.162	< 0.55	69.5	48.8	106.
	60-70	0.198	< 0.55	63.5	49.0	100.
46	0-10	0.145	< 0.55	75.0	56.0	108.
	30-40	< 0.132	< 0.55	80.0	55.0	108.
	60-70	< 0.133	< 0.55	76.5	54.0	115.
47	0-10	0.136	< 0.55	84.0	57.0	108.
	30-40	0.242	< 0.55	76.0	48.8	100.
	60-70	0.227	< 0.55	69.5	47.3	89.5
48	0-10	0.160	< 0.55	85.5	58.0	118.
	30-40	0.154	< 0.55	74.5	51.5	110.
	60-70	< 0.133	< 0.55	73.5	46.1	104.

*All results expressed in ug/g dry weight

Continued...

TABLE 1 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, JULY 1980 (Continued)

Coordinates: 49°15.4'N, 123°22.1'W

STATION	DEPTH (cm)	Hg	Cd	Pb	Cu	Zn
49	0-10	0.148	< 0.55	68.0	42.0	110.
	30-40	0.201	< 0.55	62.0	42.9	108.
	60-70	0.152	< 0.55	75.0	46.6	93.5
50	0-10	0.236	< 0.55	73.0	47.3	107.
	30-40	< 0.121	< 0.55	79.5	51.5	117.
	60-70	< 0.128	< 0.55	66.0	43.8	91.5

*All results expressed in ug/g dry weight

TABLE 2 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, MARCH 1982 - CORE SAMPLES

Coordinates: 49°15.4'N, 123°22.1'W

STATION	DEPTH (cm)	Hg	Cd	Pb	Cu	Zn
7	0-10	0.39	0.3	23	47.2	104.
25	0-10	0.48	0.5	28	47.9	108.
26	0-10	0.40	0.4	27	50.1	99.8
	30-40	0.34	< 0.2	19	47.0	101.
	60-70	0.27	0.3	17	44.9	95.3
27	0-10	0.38	0.4	21	41.4	87.3
28	0-10	0.38	< 0.2	21	45.3	97.2
	30-40	0.46	< 0.2	20	46.8	105.
	60-70	0.36	< 0.2	19	48.1	104.
29	0-10	0.44	0.5	23	49.4	97.5
30	0-10	0.44	< 0.2	22	45.0	103.
	30-40	0.42	< 0.2	20	48.5	103.
	60-70	0.36	< 0.2	18	47.8	99.4
31	0-10	0.46	0.3	31	52.4	102.
32	0-10	0.51	< 0.2	28	57.2	124.
	30-40	0.40	0.4	22	52.9	111.
	60-70	0.29	< 0.2	17	49.1	97.7
34	0-10	0.38	0.4	27	48.3	98.3
36	0-10	0.39	0.5	27	48.9	110.
38	0-10	0.38	0.4	27	44.5	91.6
40	0-10	0.38	< 0.2	21	42.4	76.2
41	0-10	0.36	0.4	28	47.3	109.
	30-40	0.36	0.5	17	46.5	99.7
	60-70	0.38	< 0.2	20	49.8	106.

*All results expressed in ug/g dry weight

TABLE 3 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, NOVEMBER 1982

Coordinates: 49°15.4'N, 123°22.1'W

STATION	Hg	Cd	Pb	Cu	Zn
7	0.25	< 0.3	15	43.2	109
17	0.20	< 0.3	22	42.3	105
18	0.20	< 0.3	10	38.8	98.2
19	0.18	< 0.3	14	45.8	104
25	0.14	1.9	15	35.8	91.1
26	0.17	< 0.3	10	34.8	77.7
27	0.16	22.0	25	43.8	92.2
28	0.14	1.7	12	35.8	99.2
29	0.19	< 0.3	14	43.7	107
30	0.18	< 0.3	15	42.3	102
31	0.15	1.4	12	39.2	89.8
32	0.17	< 0.3	15	40.5	96
34	0.07	< 0.3	< 3	25.9	55.3
36	0.21	< 0.3	14	40.9	98.4
38	0.16	< 0.3	15	35.5	90.7
40	0.12	< 0.3	9	22.6	52.5
41	0.13	< 0.3	160	29.7	77.9
49	0.28	< 0.3	76	131	375
50	0.19	< 0.3	12	44.1	98.8
REFERENCE MATERIALS (November 1982)					
MESS-1 Marine Sediments					
Certified	0.59 ± 0.10		34.0 ± 6.1	25.1 ± 38	191 ± 17
Found	< 0.5		26	24.0	184
BCSS-1 Marine Sediments					
Certified	0.25 ± 0.04		22.7 ± 3.4	18.5 ± 2.7	119 ± 12
Found	< 0.5		18	17.0	120

*All results expressed in ug/g dry weight

TABLE 4 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH POPULATION MEAN AND POPULATION STANDARD DEVIATION - SEPTEMBER 1983, GRAB SAMPLES

STATION	Hg	Cd	Pb	Cu	Zn
1 a	0.22	1.3	21	53.5	121
b	0.22	0.8	18	52.2	117
c	0.20	0.9	19	50.6	116
	0.21 ± 0.01	1.0 ± 0.3	19 ± 2	52.1 ± 1.5	118 ± 3
2 a	0.17	0.7	22	59.6	116
b	0.16	1.0	25	61.3	121
c	0.19	0.9	22	59.3	117
	0.17 ± 0.02	0.9 ± 0.2	23 ± 2	60.1 ± 1.1	118 ± 3
3 a	0.14	0.9	14	45.6	103
b	0.15	1.4	12	43.5	102
c	0.14	1.1	13	44.3	104
	0.14 ± 0.01	1.1 ± 0.2	13 ± 1	44.5 ± 1.1	103 ± 1
4 a	0.15	0.8	14	46.0	111
b	0.15	0.8	12	46.6	113
c	0.18	2.9	14	46.6	112
	0.16 ± 0.02	1.5 ± 1.2	13 ± 1	46.4 ± 0.4	112 ± 1
5 a	0.22	0.6	14	44.0	111
b	0.22	1.0	11	45.0	111
c	0.11	0.7	14	44.6	111
	0.18 ± 0.06	0.77 ± 0.21	13 ± 2	44.5 ± 0.5	111 ± 0
6 a	0.12	0.7	17	45.4	114
b	0.13	0.7	13	44.6	114
c	0.13	0.9	15	45.3	113
	0.13 ± 0.01	0.8 ± 0.2	15 ± 2	45.1 ± 0.4	114 ± 1
7 a	0.16	0.8	19	52.6	127
b	0.16	0.7	20	51.2	125
c	0.17	0.6	17	50.3	125
	0.16 ± 0.01	0.7 ± 0.1	19 ± 2	51.9 ± 1.0	126 ± 1
8 a	0.16	0.8	23	57.7	126
b	0.18	0.8	24	59.0	126
c	0.17	0.8	26	58.6	127
	0.17 ± 0.01	0.8 ± 0	24 ± 2	58.4 ± 0.7	126 ± 1
25 a	0.15	0.7	25	50.5	116
b	0.22	0.6	22	50.1	115
c	0.13	0.8	25	47.8	119
	0.17 ± 0.05	0.7 ± 0.1	24 ± 2	49.5 ± 1.5	117 ± 2

*All results expressed in ug/g dry weight

Continued...

TABLE 4 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH POPULATION MEAN AND POPULATION STANDARD DEVIATION - SEPTEMBER 1983, GRAB SAMPLES (Continued)

STATION		Hg	Cd	Pb	Cu	Zn
25	a	0.13	0.8	21	50.3	125
	b	0.12	0.7	19	50.2	116
	c	0.13	0.8	21	47.8	119
		0.13 ± 0.01	0.8 ± 0.1	20 ± 1	50.1 ± 0.2	120 ± 5
26	a	0.12	0.7	23	47.8	118
	b	0.12	0.8	26	47.3	121
	c	0.14	0.7	31	50.8	134
		0.13 ± 0.01	0.7 ± 0.1	26 ± 4	48.6 ± 1.9	124 ± 9
27	a	0.16	0.7	21	44.2	117
	b	0.17	0.7	22	46.3	114
	c	0.19	0.8	22	46.7	123
		0.17 ± 0.02	0.7 ± 0.1	21 ± 1	45.7 ± 1.3	118 ± 5
27	a	0.15	0.8	17	44.7	111
	b	0.22	1.0	38	51.2	144
	c	0.19	0.8	41	54.6	150
		0.19 ± 0.04	0.9 ± 0.1	32 ± 13	50.2 ± 5.0	135 ± 21
28	a	0.12	0.8	18	45.1	114
	b	0.19	0.8	16	46.9	114
	c	0.20	0.6	16	41.5	107
		0.17 ± 0.04	0.7 ± 0.1	17 ± 1	44.5 ± 2.8	111 ± 4
28	a	0.18	0.7	14	44.0	106
	b	0.18	0.8	13	44.7	110
	c	0.18	0.8	14	43.9	106
		0.18 ± 0	0.8 ± 0.1	13 ± 1	44.2 ± 0.4	107 ± 2
29	a	0.24	0.7	13	39.2	104
	b	0.25	0.7	12	42.4	107
	c	0.31	0.7	14	44.4	110
		0.27 ± 0.04	0.7 ± 0	13 ± 1	42 ± 2.6	107 ± 3
30	a	0.18	0.8	14	45.6	113
	b	0.16	0.7	15	46.0	109
	c	0.19	0.7	13	48.3	122
		0.17 ± 0.02	0.8 ± 0.1	14 ± 1	46.6 ± 1.5	114 ± 7
31	a	0.16	0.6	16	48.9	113
	b	0.17	0.6	18	46.3	107
	c	0.18	0.6	18	50.9	114
		0.17 ± 0.01	0.6 ± 0	17 ± 1	48.7 ± 2.3	111 ± 4

*All results expressed in ug/g dry weight

Continued...

TABLE 4 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH POPULATION MEAN AND POPULATION STANDARD DEVIATION - SEPTEMBER 1983, GRAB SAMPLES (Continued)

STATION		Hg	Cd	Pb	Cu	Zn
31	a	0.19	0.7	19	50.5	117
	b	0.16	0.7	19	48.6	115
	c	0.15	0.7	17	48.6	114
		0.17 ± 0.02	0.7 ± 0	18 ± 1	49.2 ± 1.1	115 ± 2
32	a	0.15	0.6	16	45.1	103
	b	0.15	0.7	21	47.9	105
	c	0.15	0.7	26	50.8	112
		0.15 ± 0	0.7 ± 0.1	21 ± 5	47.9 ± 2.9	107 ± 5
33	a	0.13	0.7	19	42.4	95.8
	b	0.15	0.8	18	43.1	99.4
	c	0.20	0.7	38	48.3	118
		0.16 ± 0.04	0.7 ± 0.1	25 ± 11	44.6 ± 3.2	104 ± 12
34	a	0.26	0.6	33	45.1	128
	b	0.25	2.2	25	50.3	114
	c	0.22	0.8	27	46.7	118
		0.23 ± 0.02	1.2 ± 0.9	28 ± 4	47.4 ± 2.7	120 ± 7
35	a	0.18	0.6	18	44.8	106
	b	0.16	0.6	17	42.8	101
	c	0.22	0.8	18	46.1	106
		0.19 ± 0.03	0.7 ± 0.1	18 ± 1	44.6 ± 1.7	104 ± 3
36	a	0.15	0.7	13	40.3	99.3
	b	0.18	0.8	16	42.4	104
	c	0.18	0.8	17	43.6	106
		0.17 ± 0.02	0.8 ± 0.1	15 ± 2	42.1 ± 1.7	103 ± 3
37	a	0.20	0.8	19	42.2	108
	b	0.18	0.8	22	48.3	109
	c	0.17	0.8	24	42.6	107
		0.18 ± 0.02	0.8 ± 0	22 ± 2	44.4 ± 3.4	108 ± 1
38	a	0.18	0.5	12	40.9	101
	b	0.22	0.8	14	42.0	103
	c	0.18	0.4	13	39.3	95.9
		0.19 ± 0.02	0.6 ± 0.2	13 ± 1	40.7 ± 1.4	100 ± 4

*All results expressed in ug/g dry weight

Continued...

TABLE 4 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH POPULATION MEAN AND POPULATION STANDARD DEVIATION - SEPTEMBER 1983, GRAB SAMPLES
(Continued)

STATION	Hg	Cd	Pb	Cu	Zn
39 a	0.16	0.9	23	43.6	99.3
b	0.18	0.8	19	41.6	101
c	0.18	0.7	16	45.0	105
	0.17 ± 0.01	0.8 ± 0.1	19 ± 4	43.4 ± 1.7	102 ± 3
40 a	0.18	0.8	19	46.0	110
b	0.18	0.9	23	44.3	126
c	0.18	0.7	19	45.2	108
	0.18 ± 0	0.8 ± 0.1	20 ± 2	45.2 ± 0.8	115 ± 10
41 a	0.18	0.8	24	45.8	163
b	0.15	1.1	37	41.5	133
c	0.15	0.8	27	40.2	132
	0.16 ± 0.02	0.9 ± 0.2	29 ± 7	42.5 ± 2.9	143 ± 18
REFERENCE MATERIALS (September, 1983)					
MESS-1					
Certified	0.17 ± 0.01	0.59 ± .10	34.0 ± 6.1	25.1 ± 3.8	191 ± 17
Found	0.21	0.8	24	23.2	161
		1.0	30	24.3	184
BCSS-1					
Certified	0.13 ± 0.01	0.25 ± 0.04	22.7 ± 3.4	18.5 ± 2.7	119 ± 12
Found	0.19	0.5	18	14.5	104
		0.4	17	16.5	111
		0.5	19	16.1	114

*All results expressed in ug/g dry weight

TABLE 5 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH SAMPLE MEAN AND SAMPLE STANDARD DEVIATION - NOVEMBER 1983

STATION	Hg**	Cd	Pb	Cu	Zn
1 a)	0.234	0.5	18	52.4	116
		N.D.	17	51.4	116
		0.3	19	53.0	115
			18 ± 1	52.3 ± 0.8	116 ± 1
b)	0.237	0.5	18	53.0	117
		0.5	19	51.6	116
		0.5 ± 0	18 ± .7	52.3 ± 1.0	116 ± 1
2 a)	0.197	N.D.	23	57.0	119
		N.D.	26	57.8	118
			25 ± 2	57.4 ± 0.6	118 ± 1
b)	0.200	N.D.	32	58.3	119
		N.D.	30	58.0	119
			31 ± 1	58.2 ± 0.2	119 ± 0
3 a)	0.152	N.D.	13	45.1	99.7
		N.D.	12	45.8	101
		N.D.	14	45.1	99.9
			13 ± 1	45.3 ± 0.4	100 ± 1
b)	0.150	N.D.	13	46.5	102
		N.D.	15	45.9	101
			14 ± 1	46.2 ± 0.4	101 ± 1
4 a)	0.175	.6	13	47.4	111
		.5	13	47.7	112
		0.6 ± 0.1	13 ± 0	47.6 ± 0.2	111 ± 1
b)	0.176	0.3	14	46.6	110
		0.3	12	45.2	109
		0.3 ± 0	13 ± 1	45.9 ± 1.0	109 ± 1
5 a)	0.165	N.D.	13	41.2	104
		0.3	15	41.4	105
			14 ± 1	41.3 ± 0.1	104 ± 1
b)	0.194	0.3	13	42.5	106
		0.5	13	43.1	107
		N.D.	9	33.3	82.8
			12 ± 2	39.6 ± 5.5	98.6 ± 13.7

*All results expressed in ug/g dry weight
**Mercury results are averages of duplicate analysis results

Continued...

TABLE 5 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH SAMPLE MEAN AND SAMPLE STANDARD DEVIATION - NOVEMBER 1983 (Continued)

STATION	Hg**	Cd	Pb	Cu	Zn
6 a)	0.225	0.4 0.5 0.4 ± 1.0	13 15 14 ± 1	44.7 44.7 45.7 ± 0	111 112 111 ± 1
b)	0.199	.5 .4 0.4 ± 1.0	15 14 14 ± 1	45.2 45.0 45.1 ± 0.1	112 111 115 ± 1
7 a)	0.200	0.6 0.6 0.6 ± 0	18 18 18 ± 0	48.4 48.9 48.6 ± 0.4	116 115 116 ± 1
b)	0.356	N.D. N.D.	17 16 16 ± 1	47.1 47.7 47.4 ± 0.4	113 113 113 ± 0
25 a)	0.233	0.4 0.5 0.4 ± 0.1	23 25 24 ± 1	47.3 46.1 46.7 ± 0.8	114 111 113 ± 2
b)	0.222	N.D. N.D.	23 21 22 ± 1	47.7 47.0 47.4 ± 0.5	106 107 107 ± 1
26 a)	0.271	0.8 0.8 0.8 ± 0	53 52 52 ± 1	42.0 38.9 40.5 ± 2.2	113 113 113 ± 0
b)	0.240	0.7 0.7 0.7 0.7 ± 0	34 41 34 36 ± 4	45.7 45.9 45.4 45.7 ± 0.2	108 108 105 107 ± 2
27 a)	0.220	0.4 N.D.	16 17 16 ± 1	44.2 46.7 45.5 ± 1.8	102 102 102 ± 0
b)	0.173	0.4 0.5 0.4 ± 0.1	17 17 17 ± 0	44.4 44.0 44.2 ± 0.3	106 104 105 ± 1

*All results expressed in ug/g dry weight
**Mercury results are averages of duplicate analysis results

Continued...

TABLE 5 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH SAMPLE MEAN AND SAMPLE STANDARD DEVIATION - NOVEMBER 1983 (Continued)

STATION	Hg**	Cd	Pb	Cu	Zn
32 a)	0.196	0.3 0.3 0.5 0.4 ± 0.1	23 21 30 25 ± 5	45.0 44.9 47.3 45.7 ± 1.4	104 105 108 106 ± 2
b)	0.224	0.4 0.4 0.4 ± 0	18 24 21 ± 4	47.4 48.3 47.9 ± 0.6	106 109 108 ± 2
33 a)	0.322	1.6 1.6 1.8 1.7 ± 0.1	55 53 54 54 ± 1	55.9 56.1 57.2 56.4 ± 0.7	135 143 143 140 ± 5
b)	0.345	0.7 0.7 0.7 ± 0	37 36 46 ± 1	46.2 43.6 57.2 ± 2.1	126 128 143 ± 2
35 a)	0.220	0.4 0.6 0.6 0.5 ± 0.1	36 43 37 39 ± 4	44.0 46.5 47.7 46.1 ± 1.9	135 132 131 133 ± 2
b)	0.215	0.4 0.5 0.4 ± 0.1	37 36 36 ± 1	46.2 43.6 44.9 ± 1.8	126 128 127 ± 1
36 a)	0.225	0.5 0.6 0.6 ± 0.1	19 21 20 ± 1	45.6 48.5 47.0 ± 2.0	107 107 107 ± 0
b)	0.225	0.7 0.7 0.7 ± 0	17 16 16 ± 1	46.0 46.4 46.2 ± 0.3	108 110 109 ± 1
37 a)	0.209	0.5 0.5 0.5 ± 0	46 47 46 ± 1	62.6 66.0 64.3 ± 2.4	116 117 116 ± 1
b)	0.176	1.2 1.3 1.2 ± 0.1	29 30 30 ± 1	43.4 47.0 45.2 ± 2.6	108 106 107 ± 1

*All results expressed in ug/g dry weight
**Mercury results are averages of duplicate analysis results

Continued...

TABLE 5 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH SAMPLE MEAN AND SAMPLE STANDARD DEVIATION - NOVEMBER 1983
(Continued)

STATION	Hg**	Cd	Pb	Cu	Zn
37A a)	0.196	N.D. N.D. —	26 20 23 ± 4	48.4 54.4 51.4 ± 4.2	103 106 104 ± 2
b)	0.250	3.2 3.4 3.3 3.3 ± 0.1	18 18 18 18 ± 0	42.3 42.5 42.4 42.4 ± 0.1	103 103 108 105 ± 3
39 a)	0.223	1.9 1.7 1.8 ± 0.1	23 24 24 ± 1	46.0 44.9 45.4 ± 0.8	104 103 104 ± 1
b)	0.234	0.9 0.9 0.9 ± 0	32 32 32 ± 0	45.7 45.0 45.4 ± 0.5	107 106 106 ± 1
40 a)	0.250	2.3 2.3 2.3 ± 0	34 35 34 ± 1	56.4 54.7 55.6 ± 1.2	118 117 118 ± 1
b)	0.222	0.8 0.9 0.7 0.8 ± 0.1	24 26 26 25 ± 1	52.9 50.6 52.7 52.1 ± 1.3	112 120 116 116 ± 4
41 a)	0.201	3.2 3.2 3.2 ± 0	25 25 25 ± 0	41.8 40.0 40.9 ± 1.3	102 95.6 99 ± 4
b)	0.350	0.7 0.7 0.7 ± 0	31 29 30 ± 1	50.7 50.4 50.6 ± 0.2	124 122 123 ± 1

*All results expressed in ug/g dry weight
**Mercury results are averages of duplicate analysis results

Continued...

TABLE 5 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, WITH SAMPLE MEAN AND SAMPLE STANDARD DEVIATION - NOVEMBER 1983 (Continued)

STATION	Hg**	Cd	Pb	Cu	Zn
REFERENCE MATERIALS (November 1983)					
MESS-1 Marine Sediments					
Certified		0.59 + 0.10	34 + 6.1	25.1 + 3.8	191 + 17
***RS-1 Found		0.6	29	25.3	175
		0.6	28	23.5	181
RS-2 Found		< 0.3	27	25.4	176
		< 0.3	28	23.6	180
BCSS-1 Marine Sediments					
Certified		0.25 + 0.04	22.7 + 3.4	18.5 + 2.7	119 + 12
RS-1 Found		< 0.3	19	15.9	108
		< 0.3	19	16.4	107
RS-2 Found		< 0.3	18	15.6	108
		< 0.3	19	15.5	105
MESS-1 Marine Sediments					
Certified	0.17 + 0.01				
Found	0.220				
BCSS-1 Marine Sediments					
Certified	0.13 + 0.01				
Found	0.171				

*All results expressed in ug/g dry weight
**Mercury results are averages of duplicate analysis results
***RS-1 reference materials run with stations 33, 39 and 40
RS-2 reference materials run with all other stations

TABLE 6 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, APRIL 1984 - CORE SAMPLES

STATION	DEPTH (cm)	Hg	Cd	Pb	Cu	Zn
1	0-10	0.101	**N.D. (0.3)	13	46.0	111
	30-40	0.185	N.D. (0.3)	6	44.8	104
	60-70	0.107	N.D. (0.3)	4	46.7	114
2	0-10	0.242	N.D. (0.3)	32	66.7	145
	30-40	0.135	N.D. (0.3)	10	51.5	123
	60-70	0.112	N.D. (0.3)	4	49.6	118
3	0-10	0.130	N.D. (0.3)	13	44.0	108
	30-40	0.130	N.D. (0.3)	8	44.8	112
	60-70	0.130	N.D. (0.3)	10	44.8	112
4	0-10	0.231	N.D. (0.3)	11	49.4	124
	30-40	0.164	N.D. (0.3)	15	47.9	122
	60-70	0.118	N.D. (0.3)	11	48.9	121
5	0-10	0.192	N.D. (0.3)	13	46.1	122
	30-40	0.141	N.D. (0.3)	8	47.1	124
	60-70	0.174	N.D. (0.3)	12	44.6	118
6	0-10	0.209	N.D. (0.3)	15	46.7	125
	30-40	0.193	N.D. (0.3)	14	50.3	127
	60-70	0.163	N.D. (0.3)	14	46.3	122
7	0-10	0.195	N.D. (0.3)	13	51.9	134
	30-40	0.220	N.D. (0.3)	9	46.8	112
	60-70	0.197	N.D. (0.3)	7	40.2	109
8	0-10	0.157	N.D. (0.3)	20	58.1	140
	30-40	0.095	N.D. (0.3)	4	49.8	116
	60-70	0.085	N.D. (0.3)	< 3	42.7	116
25	0-10	0.113	N.D. (0.3)	22	61.1	194
	30-40	0.113	N.D. (0.3)	8	52.0	128
	60-70	0.101	N.D. (0.3)	5	46.4	114
26	0-10	0.294	N.D. (0.3)	48	52.7	155
	30-40	0.117	N.D. (0.3)	6	47.8	120
	60-70	0.112	N.D. (0.3)	3	48.7	112

*All results expressed in ug/g dry weight
**Not detected (number in brackets represents the limit of detection)

Continued...

TABLE 6 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, APRIL 1984 - CORE SAMPLES

(Continued)

STATION	DEPTH (cm)	Hg	Cd	Pb	Cu	Zn
27	0-10	0.236	N.D. (0.3)	17	46.1	125
	30-40	0.124	N.D. (0.3)	8	48.7	125
	60-70	0.117	N.D. (0.3)	8	46.4	113
28	0-10	0.117	N.D. (0.3)	15	47.9	130
	30-40	0.179	N.D. (0.3)	13	47.5	123
	60-70	0.174	N.D. (0.3)	7	46.5	113
29	0-10	0.140	N.D. (0.3)	16	48.7	129
	30-40	0.107	N.D. (0.3)	6	46.5	121
	60-70	0.107	N.D. (0.3)	5	46.4	113
30	0-10	0.140	N.D. (0.3)	10	48.5	128
	30-40	0.117	N.D. (0.3)	10	49.1	126
	60-70	0.101	N.D. (0.3)	6	45.7	112
31	0-10	0.196	N.D. (0.3)	16	54.3	137
	30-40	0.080	N.D. (0.3)	3	45.4	114
	60-70	0.106	N.D. (0.3)	7	47.8	116
32	0-10	0.146	N.D. (0.3)	18	60.5	140
	30-40	0.134	N.D. (0.3)	11	52.1	131
	60-70	0.106	N.D. (0.3)	4	46.7	116
33	0-10	0.112	N.D. (0.3)	28	49.0	120
	30-40	0.139	N.D. (0.3)	11	49.7	128
	60-70	0.096	N.D. (0.3)	7	48.8	117
34	0-10	0.101	N.D. (0.3)	13	41.7	102
	30-40	0.112	N.D. (0.3)	7	46.8	123
	60-70	0.101	N.D. (0.3)	4	45.0	109
35	0-10	0.106	N.D. (0.3)	22	41.1	99.9
	30-40	0.145	N.D. (0.3)	13	47.2	124
	60-70	0.129	N.D. (0.3)	11	47.6	122

*All results expressed in ug/g dry weight

Continued...

TABLE 6 POINT GREY OCEAN DUMP SITE - TRACE METAL CONCENTRATIONS* IN BENTHIC SEDIMENTS, APRIL 1984 - CORE SAMPLES

(Continued)

STATION	DEPTH (cm)	Hg	Cd	Pb	Cu	Zn
36	0-10	0.156	N.D. (0.3)	17	47.8	122
	30-40	0.123	N.D. (0.3)	9	48.3	124
	60-70	0.129	N.D. (0.3)	10	46.5	118
37	0-10	0.168	N.D. (0.3)	16	49.9	134
	30-40	0.157	N.D. (0.3)	12	47.1	124
	60-70	0.128	N.D. (0.3)	12	45.2	115
38	0-10	0.161	N.D. (0.3)	16	50.0	126
	30-40	0.124	N.D. (0.3)	8	49.4	124
	60-70	0.124	N.D. (0.3)	6	46.6	116
39	0-10	0.146	N.D. (0.3)	26	52.0	136
	30-40	0.140	N.D. (0.3)	7	50.4	127
	60-70	0.107	N.D. (0.3)	4	44.5	111
40	0-10	0.080	N.D. (0.3)	12	40.8	99.4
	30-40	0.113	N.D. (0.3)	7	49.7	128
	60-70	0.101	N.D. (0.3)	6	46.9	114
41	0-10	0.140	N.D. (0.3)	19	47.1	120
	30-40	0.151	N.D. (0.3)	10	47.3	123
	60-70	0.122	N.D. (0.3)	9	46.4	112

*All results expressed in ug/g dry weight

TABLE 7 PRECISION DATA* WITH SAMPLE MEAN AND SAMPLE STANDARD DEVIATION FOR TABLE 6, APRIL 1984

STATION	Hg	Cd	Pb	Cu	Zn
4a	0.236	**N.D. (0.3)	14	48.5	119
	0.260	N.D. (0.3)	14	48.3	118
	0.270	N.D. (0.3)	15	49.0	118
	0.265	N.D. (0.3)	15	48.3	118
	0.231	N.D. (0.3)	11	49.4	124
	0.252 ± 0.018	-	14 ± 2	48.7 ± 0.5	119 ± 3
6b	0.213	N.D. (0.3)	14	48.3	121
	0.195	N.D. (0.3)	15	48.1	122
	0.185	N.D. (0.3)	15	48.2	124
	0.166	N.D. (0.3)	15	47.8	125
	0.193	N.D. (0.3)	14	50.3	127
	0.190 ± 0.017	-	15 ± 0	48.5 ± 1.0	123 ± 2
8c	0.174	N.D. (0.3)	15	48.3	125
	0.172	N.D. (0.3)	12	48.0	126
	0.105	N.D. (0.3)	6	43.4	111
	0.105	N.D. (0.3)	7	42.4	109
	0.085	N.D. (0.3)	N.D.(0.3)	42.7	116
	0.128 ± 0.040	-		44.9 ± 2.9	117 ± 8
26a	0.105	N.D. (0.3)	6	42.5	110
	0.105	N.D. (0.3)	6	42.7	110
	0.073	N.D. (0.3)	6	43.7	112
	0.352	N.D. (0.3)	49	52.0	150
	0.294	N.D. (0.3)	48	52.7	155
	0.186 ± 0.130	-	23 ± 23	46.7 ± 5.2	127 ± 23

*All results expressed in ug/g dry weight
**Not detected (number in brackets represents the limit of detection)

Continued...

TABLE 7 PRECISION DATA* WITH SAMPLE MEAN AND SAMPLE STANDARD DEVIATION FOR TABLE 6, APRIL 1984

(Continued)

STATION	Hg	Cd	Pb	Cu	Zn
28b	0.374	N.D. (0.3)	51	52.4	155
	0.352	N.D. (0.3)	50	53.6	153
	0.438	N.D. (0.3)	49	52.1	152
	0.373	N.D. (0.3)	50	52.3	149
	0.179	N.D. (0.3)	13	47.5	123
	0.340 ± 0.100	-	43 ± 17	51.6 ± 2.6	146 ± 13
30c	0.128	N.D. (0.3)	9	47.6	120
	0.124	N.D. (0.3)	8	47.8	121
	0.128	N.D. (0.3)	10	47.4	121
	0.139	N.D. (0.3)	8	47.3	121
	0.101	N.D. (0.3)	6	45.7	112
	0.126 ± 0.015	-	8 ± 2	47.2 ± 0.8	119 ± 4
33a	0.117	0.5	6	47.8	122
	0.079	N.D. (0.3)	18	16.1	114
	0.074	N.D. (0.3)	5	46.2	111
	0.096	N.D. (0.3)	N.D.(0.3)	45.7	110
	0.112	N.D. (0.3)	28	49.0	120
	0.096 ± 0.020	-	-	41.0 ± 14.0	115 ± 5

*All results expressed in ug/g dry weight

TABLE 8 ACUCRACY DATA FOR TABLE 6 - APRIL, 1984

STATION	Hg	Cd	Pb	Cu	Zn
MESS-1					
Certified	0.17 ± 0.01	0.59 ± 0.10	34.0 ± 6.1	25.1 ± 3.8	191 ± 17
Found	0.195	0.5	34	24.2	183
	0.090	0.5	30	27.7	186
	0.207	0.3	25	23.0	182
BCSS-1					
Certified	0.13 ± 0.01	0.25 ± 0.04	22.7 ± 3.4	18.5 ± 2.7	119 ± 12
	0.167	N.D. (0.3)	16	16.3	112
	0.155	N.D. (0.3)	20	16.5	113
	0.161	N.D. (0.3)	18	15.7	111

*All results expressed in ug/g dry weight

TABLE 9 TRACE METAL CONCENTRATIONS* IN BENTHIC FAUNA, POINT GREY OCEAN DUMPSITE, NOVEMBER 1982 - TRAWL SAMPLES

	Cd	Hg	Pb	Cu	Zn
TRAWL 1					
Pandalopsis dispar - whole body	1.9	0.06	1.0	107	53.3
Microstomus pacificus - muscle	< 0.1	0.07	< 1	6.6	28.0
Sebastes aleutianus - muscle	< 0.1	0.20	1.0	1.8	18.2
Sebastes aleutianus - liver	0.6	0.28	< 1	7.4	34.4
TRAWL 2					
Pandalopsis dispar - whole body	2.2	0.03	2.0	112	55.7
Sebastes sp. - muscle	< 0.1	0.14	< 1	19.8	39.9
Sebastes sp. - liver	4.1	0.15	< 1	14.5	101

*All results expressed in ug/g dry weight

TABLE 10 TRACE METAL CONCENTRATIONS* IN *Molpadia intermedia* POINT GREY OCEAN DUMPSITE, NOVEMBER 1982 - GRAB SAMPLES

STATION	Cd	Hg	Pb	Cu	Zn
17	< 0.5	0.03	12.0	30.0	77.2
18	< 0.1	0.03	10.0	24.5	73.4
19	< 0.1	0.02	7.0	29.8	73.4
26	< 0.1	0.02	5.0	18.9	53.4
27	< 0.1	0.03	12.0	22.4	69.1
29	< 0.5	0.07	< 5	21.0	80.2
30	< 0.1	0.03	7.0	23.2	57.9
31	< 0.5	0.02	< 5	14.0	79.7
32	< 0.5	0.03	9.0	24.0	56.8
41	< 0.5	0.02	6.0	15.0	61.3
49	< 0.3	0.03	44.0	79.5	245
50	< 0.1	0.07	14.0	28.7	74.3

*All results expressed as ug/g dry weight.

TABLE 11 TRACE METAL CONCENTRATIONS* IN BENTHIC FAUNA, POINT GREY OCEAN DUMPSITE, SEPTEMBER 1983 - TRAWL SAMPLES

SAMPLE	Hg	Cd	Pb	Cu	Zn
TRAWL 1					
Pandalopsis dispar (whole body 6-8)	0.30	1.6	1	105	50.9
	0.29	1.6	< 1	107	53.4
Pandalopsis dispar (whole body 6-8)	0.28	1.7	1	116	55.1
	0.26	1.6	1	105	59.2
Sebastolobus sp.	0.21	0.2	< 1	4.4	15.1
	0.27	0.2	< 1	3.7	15.3
Sebastolobus sp.	0.27	< 0.1	< 1	2.7	11.5
	0.31	< 0.1	< 1	3.2	12.9
Pandalus platyceros (whole body 2)	0.18	0.4	1	55.2	52.7
	0.16	0.38	1.5	59.9	57.2
Pandalus platyceros (whole body 2)	0.23	0.5	1	79.3	60.6
	0.19	0.5	2	86.1	64.9
Lyopsetta exilis	0.84	< 0.1	< 1	19.6	39.8
	0.98	< 0.1	< 1	19.6	36.7
TRAWL 2					
Pandalopsis dispar (whole body 6-8)	0.3	1.9	< 1	95.5	54.2
	0.26	1.9	2	93	52.2
Pandalopsis dispar (whole body 6-8)	0.27	1.5	< 1	99.1	48.7
	0.27	1.4	2	97.1	47.9
Lyopsetta exilis	1.4	< 0.1	< 1	7.4	22.4
	0.93	< 0.1	1	7.6	22.3
Lyopsetta exilis	0.8	< 0.1	1	1.3	28.5
	0.81	< 0.1	< 1	1.3	29.2
Lyopsetta exilis	0.66	< 0.1	< 1	2.4	19.6
	0.73	< 0.1	< 1	2.5	19.8
Sebastolobus sp.	0.38	< 0.1	< 1	2.4	16.0
	0.43	< 0.1	< 1	3.4	14.4

* All results expressed in ug/g dry weight

Continued...

TABLE 11 TRACE METAL CONCENTRATIONS* IN BENTHIC FAUNA, POINT GREY OCEAN DUMPSITE, SEPTEMBER 1983 - TRAWL SAMPLES

(Continued)

SAMPLE	Hg	Cd	Pb	Cu	Zn
Sebastolobus sp.	0.41	< 0.1	< 1	1.3	15.0
	0.42	< 0.1	< 1	2.9	11.7
		< 0.1	< 1	2.8	12.0
Sebastolobus sp.	0.80	< 0.1	< 1	1.0	16.4
	0.96	< 0.1	< 1	0.9	16.9
Cancer magister	2.52	0.4	13	37.4	455
(Body and leg meat)	3.26	0.5	12	37.5	452
Pandalus sp.	0.37	1.7	2	104	66.2
(whole body 12-14)	0.38	1.8	2	113	69.1
Pandalus sp.	0.57	2.1	1	110	65.6
(whole body 12-14)		2.2	2	113	67
ANALYTICAL STANDARDS					
Tuna Control					
Certified	0.95 ± 0.1				
Found	1.19				
Bovine Liver					
Certified		0.27 ± 0.04	0.34 ± 0.08	193 ± 10	130 ± 10
Found		.2	< 1.0	209	140
Oyster Tissue					
Certified		3.5 ± 0.4	0.48 ± 0.04	63.0 ± 3.5	852 ± 14
Found		3.3	< 1.0	65.4	822

*All results expressed in ug/g dry weight

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APPENDIX I

POINT GREY OCEAN DUMPSITE
SUMMARY

1976-1983

APPENDIX I POINT GREY OCEAN DUMPSITE SUMMARY, 1976-1983

YEAR	CUBIC METRES	MATERIAL	ORIGIN	AGENT	PERMIT NUMBER
1976	97 531	silt, sand	Fraser River	DPW	11
1976	7 600	silt, sand, woodwastes	Fraser River	Crown Zellerbach	13
1976	39 925	sand, silt, gravel, shells, rip-rap	Granville Island	Coast Wood, Central Mortgage	16
1976	17 813	silt, mud, sand, woodwastes	North Arm, Fraser River	MB, Vancouver Plywood	29
1976	5 351	silt, mud, sand	North Arm, Fraser River	CFP, Eburne	30
1976	917	woodwastes, silt, mud, sand	North Arm, Fraser River	Mainland Sawmills	45
1976	6 574	dredge material	Fisherman's Cove, West Vancouver	DPW	48
1976	3 800	mud, sand, gravel	Fraser River	Rivtow	119
1976	1 529	silt, sand	Fraser River	Hercules Dredging	172
1977	6 116	silt, mud, sand, woodwastes	North Arm, Fraser River	Rayonier Canada	35
1977	4 587	silt, mud, sand, woodwastes and concrete blocks	Fraser River	Weldwood	40
1977	1 452	woodwastes, silt, mud, sand	Fraser River	Terminal Sawmills	44
1977	12 670	silt, sand, gravel	Vancouver	Ocean Concrete	141
1977	8 500	sand, mud, woodwaste	Vancouver	Bay Forest Products	169
1977	22 590	silt, mud, clay, gravel, rock	False Creek	Marathon Realty	178
1977	7 600	silt, mud, woodwastes	Fraser River	Crown Zellerbach	180
1977	3 058	silt, mud, sand, woodwastes	North Arm, Fraser River	MB, Fraser River	196
1977	15 290	silt, mud, sand, woodwastes	North Arm, Fraser River	CFP, Eburne	208
1977	7 000	woodwastes, sand, gravel, rock	Vancouver Harbour and Fraser River Estuary	Dillingham	238

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APPENDIX I (Continued)

YEAR	CUBIC METRES	MATERIAL	ORIGIN	AGENT	PERMIT NUMBER
1977	8 200	silt, mud, sand, woodwastes	North Arm, Fraser River	Rayonier Canada	282
1977	59 371	woodwastes, sand, gravel, rock	Vancouver Harbour and Fraser River Estuary	Fraser River Pile Driving	296
1977	340 000	silt, clay, sand, woodwastes	North Arm, Fraser River	Rivcon Industries	322
1977	229 350	mud, sand, woodwastes	Burrard Inlet	Pioneer Grain Terminal	323
1977	6 120	clay, silt, gravel, rock	Coal Harbour	Coal Harbour Maritime	324
1977	3 800	woodwastes, silt, mud, sand	North Arm, Fraser River	Terminal Sawmills	325
1977	3 800	woodwastes, silt, mud, sand	North Arm, Fraser River	Mainland Sawmills	326
1977	1 147	mud, woodwastes	North Arm, Fraser River	Goldwood Industries	347
1977	6 000	silt, mud, sand, woodwastes	North Arm, Fraser River	Crown Zellerbach	356
1977	20 262	woodwastes, sand, gravel, rock	Vancouver Harbour and Fraser River Estuary	D.J. Byrne Construction Ltd.	367
1978	1 147	woodwastes, sand, gravel, rock	Vancouver Harbour and Fraser River Estuary	Greenless Piledriving	327
1978	1 529	sand, mud, woodwastes	False Creek	Bay Forest Products	368
1978	3 480	silt, sand, gravel, concrete	Fraser River, Burrard Inlet, Granville Island	Ocean Construction	391
1978	16 055	silt, sand, mud, woodwastes	Fraser River	CFP-Eburne	394
1978	11 000	sand, silt	North Arm, Fraser River	PWC	496
1978	2 265	woodwastes, silt, mud	Vancouver Harbour	L & K Lumber	587
1978	43,800	clay, mud, silt, woodwastes	North Arm, Fraser River	North Fraser Harbour Commission	617
1979	24 017	silt, sand, mud, woodwaste	North Arm, Fraser River	MB - Fraser River	416
1979	16 730	silt, sand, gravel	Vancouver Harbour and Fraser River Estuary	Valley Towing	450

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APPENDIX I (Continued)

YEAR	CUBIC METRES	MATERIAL	ORIGIN	AGENT	PERMIT NUMBER
1979	12 375	sand, silt, gravel, rock	Vancouver Harbour and Fraser River Estuary	Dillingham	455
1979	5 420	woodwastes, silt, sand, mud	North Arm, Fraser River	Mainland Sawmills	509
1979	3 080	woodwastes, silt, sand, mud	North Arm, Fraser River	Terminal Sawmills	510
1979	40 900	woodwastes, sand, gravel, rock	Vancouver Harbour and Fraser River Estuary	Fraser River	537
1979	9 945	woodwastes, sand, gravel, rock	Vancouver Harbour and Fraser River Estuary	Rayonier Canada	569
1979	5 350	silt, mud, sand	North Arm, Fraser River	Weldwood	594
1979	4 585	woodwastes, sand, gravel, rock	Vancouver Harbour and Fraser River Estuary	Crown Zellerbach	605
1979	7 000	woodwastes, sand, mud	False Creek	Bay Forest Products	611
1979	16 500	sand, silt, gravel, woodwastes	North Arm, Fraser River	P.W. - North Fraser	616
1979	6 655	clay, silt, sand, gravel	Coal Harbour	D.J. Byrne	640
1979	4 788	mud, sand	Snug Cove	DPW	764
1979	1 500	sand, clay, silt	Coal Harbour	Vancouver Rowing Club	836
1979	3 450	sand, silt, wood	North Arm, Fraser River Channel 13	PWC	713
1979	1 530	clay, silt, sand	Coal Harbour, Vancouver	Vancouver Rowing Club	836
1980	6 652	silt, sand, gravel	Various sites in the Lower Mainland	D.J. Byrne	642

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APPENDIX I (Continued)

YEAR	CUBIC METRES	MATERIAL	ORIGIN	AGENT	PERMIT NUMBER
1980	22 119	wood, silt, mud, sand	North Arm, Fraser River	MB-Fraser River	664
1980	1 000				665
1980	4 346	wood, silt, mud, sand	North Arm, Fraser River	CFP-Eburne Sawmills	666
1980	21 698	silt, sand, gravel	Fraser River, Lower Mainland	Valley Towing Ltd.	673
1980	10 650	silt, sand, rock	Granville Island, False Creek	CMHC	686
1980	1 500	silt, mud, sand, wood	North Arm, Fraser River	Crown Zellerbach	707
1980	18 300	silt, sand	North Arm, Fraser River	Fraser River Pile Driving	709
1980	17 012		Vancouver Harbour and Fraser River Estuary	Fraser River Pile Driving	735
1980	3 230	silt, mud, sand, wood	North Arm, Fraser River	Mainland Sawmills	762
1980	1 000	silt, mud, sand, wood	North Arm, Fraser River	Terminal Sawmills	763
1980	4 788			B.C. Highways-Snug Cove	764
1980	4 550	mud, sand, wood	False Creek	Bay Forest Products Ltd.	766
1980	1 500			Arrow Transportation Systems	779
1980	13 100	silt, mud, sand, wood	Fraser River	Rayonier Canada	785
1980	37 082	silt, clay, sand	Coal Harbour, Vancouver	Macleod Geotechnical	809
1980	12 000	clay, sand, gravel	Vancouver	Winvan Paving Ltd.	824
1980	7 500	gravel	Allied Shipyards, North Vancouver	Fraser River Pile Driving	844

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APPENDIX I (Continued)

YEAR	CUBIC METRES	MATERIAL	ORIGIN	AGENT	PERMIT NUMBER
1980	9 500	silt, sand, gravel	Point Grey Scow Moorage	NFHC	850
1981	70 000	silt, sand, gravel	North Vancouver	Burrard Yarrows Coroporation	845
1981	3 750	silt, sand	Tahsis Co. - Fraser River	Fraser River Pile Driving	849
1981	6 500	silt, mud, sand, wood	Fraser River	Crown Zellerbach	861
1981	12 500	silt, mud, sand, gravel, rock	Various sites in the Lower Mainland & Fraser River	Byrne Pile Driving	872
1981	20 680	silt, mud, sand, wood	North Arm, Fraser River	MacMillan-Bloedel	873
1981	9 828	silt, mud, sand, wood	North Arm, Fraser River	CFP-Eburne Sawmills	884
1981	3 711	clay, silt, sand, gravel	Vancouver Harbour, Fraser River	Fraser River Pile Driving	894
1981	3 825	silt, sand	North Arm, Fraser River	B.C. Forest Service, Technical Service Branch	905
1981	4 478	silt, wood	North Arm, Fraser River	Crown Zellerbach	921
1981	11 500	silt, sand, wood	Vancouver Harbour, Fraser River	Valley Towing Ltd.	923
1981	40 000	clay, silt, sand, gravel	Vancouver Harbour, Fraser River	Dillingham Corp.	956
1981	4 128	mud, sand, wood	False Creek	Bay Forest Products Ltd.	968
1981	16 311	silt, mud, sand, wood	Fraser River	Rayonier Canada	998
1981	4 000	clay, silt, sand, gravel	North Vancouver	Hooker Chemicals Div.	1001
1981	24 467	Industrial solids	Vancouver Harbour	Aime Enterprises Ltd.	1024

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APPENDIX I (Continued)

YEAR	CUBIC METRES	MATERIAL	ORIGIN	AGENT	PERMIT NUMBER
1982	3 060	mud, sand, wood	North Arm, Fraser River	Mainland Sawmills	1044
1982	3 060	mud, sand, wood	North Arm, Fraser River	Terminal Sawmills	1045
1982	22 525	sand, wood, silt, mud	North Arm, Fraser River	MacMillan-Bloedel	1053
1982	54 166	silt, sand, rock	Vancouver	Southwest Contractors Ltd.	1054
1982	3 900	silt, mud, sand, wood	North Arm, Fraser River	CFP-Eburne Sawmills	1064
1982	6 937	silt, sand, gravel, rock	Vancouver Harbour, Fraser River	Dillingham Corp.	1065
1982	3 200	silt, mud, sand, wood	North Arm, Fraser River	Crown Zellerbach	1067
1982	13 686	silt, sand, gravel, wood	Vancouver Harbour, Fraser River Estuary	Valley Towing Ltd.	1106
1982	50 000	silt, mud, sand, gravel	False Creek	Dillingham Corp.	1108
1982	60 660	silt, sand, gravel, wood	Vancouver Harbour, Fraser River	Fraser River Pile Driving	1115
1982	1 400	silt	Seapoint Marina, False Creek	Intercon Management	1116
1982	4 000	clay, silt, mud, sand, wood	Burrard Inlet	Weldwood-Flavelle Cedar	1188
1982	61 000	silt, sand, rock	False Creek	Fownes Contracting	1203
1982	11 000	sandstone	False Creek	Klondike Industries Ltd.	1210
1982	1 270	wood, mud, sand	False Creek	Bay Forest Products Ltd.	1238
1982	2,000	silt, wood	False Creek	Narod Contstruction Ltd.	1245

CONTINUED...

APPENDIX I (Continued)

YEAR	CUBIC METRES	MATERIAL	ORIGIN	AGENT	PERMIT NUMBER
1982	2 850	mud, sand, wood	North Arm, Fraser River	Mainland Sawmills	1297
1982	1 071	mud, sand, wood	False Creek	Bay Forest Products Ltd.	1391
1983	3 000	silt, mud, sand, wood	Fraser River	Western Forest Products	1242
1983	16 140	silt, mud, sand, wood	North Arm, Fraser River	MacMilland Bloedel	1268
1983	6 881	silt, wood	Coal Harbour, Vancouver	Royal Vancouver Yacht Club	1277
1983	47 350	silt, sand	Various sites in the Fraser River	PWC	1278
1983	4 300	silt, mud, sand, wood	North Arm, Fraser River	Crown Zellerbach	1279
1983	11 900	silt, mud, sand, wood	North Arm, Fraser River	CFP-Eburne Sawmills	1280
1983	3 000	silt, sand	Burrard Civic Marina	City of Vancouver, Board of Parks and Recreation	1285
1983	32 800	silt, sand, gravel, wood	Vancouver Harbour	Fraser River Pile Driving	1286
1983	8 716	silt, sand, gravel, wood	Vancouver Harbour and Fraser River Estuary	Valley Towing Ltd.	1287
1983	9 000	mud, sand, wood	North Arm, Fraser River	Terminal Sawmills	1296
1983	1 500	silt, sand, gravel, rock	Various sites in Vancouver Harbour and the Fraser River Estuary	Dillingham Corp.	1323
1983	1 147	mud, sand, gravel, rock	Vancouver Harbour	C.H. Cates & Sons Ltd.	1360

APPENDIX II

PISCES IV DIVES

PISCES IV /PANDORA II

LOCATION: Point Grey Dumpsite (See figure 5)
DATE: 09 November 1983
DIVE NUMBER: 1391
PILOT: B. Holland
OBSERVERS: H. Nelson, D. Brothers

POSITION:	Start (0935 Hrs.)	Finish (1112 Hrs.)
	49°15.4'N	49°15.7'N
	123°22.1'W	123°20.9'W

Summary: Photographic Record - Twenty 70 mm frames exposed

The dive track began at the centre of the designated spoil area in a depth of approximately 245 metres and proceeded in a north easterly direction for about three quarters of a nautical mile. The bottom on the first part of the dive was flat and composed of fairly solid light brown sediment. There was much physical evidence of dumping including steel cables and bundle ties, bricks, building blocks, boom chains, clumps of sandstone and large rocks. Benthic animals observed are listed below with brittle stars being the most numerous species. Pink and sidestripe shrimp were present as would be expected, however the numbers seemed reduced over similar areas in Georgia Strait. The marine life (ie: squat lobser, rockfish, snails, shrimp) normally associated with logs and other solid objects such as cement blocks, large rocks, etc. was also reduced.
On the second half of the dive the numbers of benthic animals decreased even more. Most noticeable was the reduction in brittle star numbers and signs of burrowing activity (ie: craters, hollows, bumps). There was still much physical evidence of dumping up to the end of the dive.

Bottom - 245 metres, 0956 hours
- centre of spoil area; proceed in northeast direction
- solid bottom, surface sediment light brown in colour
- obvious dumping activity; steel cable, bands, wood debris
- large logs covered with Neptunea sp., spider crabs, prawns (Pandalus platyceros), Actiniaria, ratfish (Hydrolagus colliei)
- brittle stars, nemerteans noted; Metridium sp.
- course heading 065°T.
- woodwaste evident; boulders, sandstone
- lemon sole (Parophrys vetulus), thornyhead rockfish (Sebastolobus sp.), sculpins
- brittle stars common; most abundant organism on dive track; concentrated in "patches"
- shrimp species noted; not common

1016 hrs - dumping activity obvious; burrowing reduced, few craters
- Dover sole (Microstomuspacificus); nemerteans associated with bark and branches
- Starfish; octopus
- concrete building blocks
- concentrations of brittle stars decreasing. Most logs have some form of life on them
- Neptunea sp., squat lobster (Munidaquadrispina), sea urchins, hermit crabs
- bottom now more depauperate since commencement of dive
- boom chains and log bundle straps noted
- large dumps of bark with spider crabs and prawns (P. platyceros) associated

1034 - 244 metres
- bottom marked with wood debris, rocks and boulders - large clumps of clay; log with octopus; bricks and cable
- mud star (Ctenodiscuscrispatus, eelpouts, brittle stars, Neptunea sp.

1050 hrs - 242 metres
- bottom type same in this portion of dive track

1100 hrs - 238 metres
- marine life more scarce
- egg cases on logs and metal bands, possibly Neptunea sp.

1112 hrs - 235 metres
- end dive

PISCES IV /PANDORA II

LOCATION: Point Grey Dumpsite (See figure 5)
DATE: 09 November 1983
DIVE NUMBER: 1392
PILOT: B. Holland
OBSERVERS: H. Nelson, D. Brothers

POSITION:	Start (1235 Hrs.)	Finish (1420 Hrs.)
	49°15.4'N	49°14.8'N
	123°22.1'W	123°23.4'W

Summary:

The dive track commenced at the centre of the designated spoil area at a depth of 245 metres and proceeded on a course of 245°T for one nautical mile (ie: to the outer perimeter of the designated spoil area.) As with the previous dive (1391) there was a lot of debris from dumping such as cable, bricks, cement pipe, bundle ties, and small clumps of rock/gravel/clay. There was more evidence of burrowing activity (ie: craters) and this increased even more towards the end of the dive. The animals normally associated with wood debris and other solid objects were again reduced. On the later half of the dive less dumped material was observed.

Bottom
- 1253 hours, 245 metres
- current one quarter km. from north
- proceed course heading 245°T
- solid bottom; obvious dumping activity, log bundle straps logs, woodwaste, small rocks, gravel, bricks
- Nemerteans, sidestripe shrimp (Pandalopsis dispar), ratfish (Hydrolagus colliei, prawns (Pandalus platyceros)
- Actiniaria sp., coiled nemerteans, Neptunea sp. noted
- visibility 2-3 metres at commencement of dive now somewhat reduced

1305 hrs - 246 metres
- brittle stars, ling cod (Ophiodonelongatus), Neptunea sp.
- hermit and spider crabs
- more evidence of burrowing activity on this dive track
- thornyhead rockfish (Sebastolobussp.)
- gravel under thin brown surface sediment layer
- squat lobster (Munida quadrispina)
- bark fragments, large plastic bucket, cement pipe
- burrowing anemones noted (Pachycerianthus sp.)
- area with dumps of grey clay sediment
- wood debris, concrete building blocks

1317 hrs - course heading 245°T, 246 metres
- both dive tracks similar; marine life scarce but noted more burrowing activity on this track
- logs with Neptunea sp., pollock (Theragra chalcogramma)

1338 hrs - 246 metres
- flat, soft bottom; obvious dumping activity bricks, cables, building blocks, concrete
- some shrimp noted

1340 hrs - 245 metres
- less dumped material, soft brown
- shrimp, brittle stars, skate noted
- Actiniaria noted throughout dive track but not numerous
- flatfish, pacific cod (Gadusmacrocephalus), pollock (T.chalcogramma), sculpins

1350 hrs - 243 metres
- area with soft bottom, light brown fine sediment layer on surface
- reduction in woodwaste and noted increase in burrowing activity
- octopus, brown cat shark (Apristurus brunneus), hake (Merluccius productus)

1355 hrs - 242 metres
- patchy duming activity evident
- thornyhead rockfish (Sebastolobus sp.) and several skat; ratfish (Hydrolagus colliei)
- after one hour on track, still encountering dumped material
- light grey sediment underlying brown surface layer; grey sediments are discharged during burrowing activity

1407 hrs - 233 metres
- END DIVE (one roll 70 mm exposed)

APPENDIX III

BENTHIC FAUNA COMMON NAMES

SPECIES	COMMON NAME
Cancer magister	Dungeness crab
Lyopsetta exilis	Slender sole
Microstromus pacificus	Dover sole
Molpadia intermedia	Sea cucumber
Pandalopsis dispar	Sidestripe shrimp
Pandalus platyceros	Prawn
Pandalus sp.	Shrimp
Sebastes aleutianus	Rougheye rockfish
Sebastes sp.	Rockfish
Sebastolobus sp.	Rockfish, thornyheads

APPENDIX IV

TRACE METAL ANALYTICAL PROCEDURES IN SEDIMENTS

(to November - December 1982)

Sediments - Trace Metals

SAMPLE PREPARATION/ANALYTICAL PROCEDURES

SCOPE AND APPLICATION

This method (Aqua regia leach) is applicable to the decomposition of sediments prior to sample analysis.

SAMPLE CONDITION

The sample should be preserved (Code 231) and prepared (Codes 236, 238) (attached). Approximately 3 to 5 g are required to analyze the sample in duplicate.

METHOD PRINCIPLE

This technique may be classed as a leach or partial extraction. It will attack the crystal lattice to various degrees depending on the sample composition. Metals from pollution sources, most sulfides and organo-metalic compounds will be included in the extract.

The advantage of using a partial extraction over a total silica destruction technique, besides the shorter analysis time, is that small but environmentally significant metal concentrations can be more often distinguished from the background concentration. Small concentration changes due to man's activities may be indistinguishable against a much larger background due to the total dissolution of the primordial material.

INTERFERENCES

1. Any decomposition of sediments results in a solution containing a large variety of ions at trace to percent levels. Such a complex matrix invariably leads to problems during analysis.

APPARATUS

1. Calibrated, 50-ml test tubes with glass stoppers.
2. Aluminum hot block with holes to accomodate the test tubes and dimensioned to fit a hot plate.
3. Hot plate.
4. Balance readable to 0.001 g.

REAGENTS

1. Hydrochloric acid, concentrated, reagent grade.
2. Nitric acid, concentrated, reagent grade.

PROCEDURE

1. Weight 0.4 to 0.5 g of freeze dried, sieved sample into a 50-ml test tube.
2. Add approximately 5 ml of deionized water, 4.5 ml of HCl and 1.5 ml HNO_3.
3. Place the tube on the hot block and heat the sample on a low heat for 3 hours. If the sample froths or bumps violently, the heat is too high.
4. Cool and dilute with deionized water to the 50 ml mark.
5. Stopper and shake well. Allow the sample to sit overnight.
6. Carefully decant the clear supernatant into a clean, acid-washed plastic bottle. Discard the residue.

CALCULATIONS

There are no calculations but the following data is recorded:

1. Tube number.
2. Sample weight (g).

PROCEDURE

Analyse sample solutions by Inductively Coupled Argon Plasma (ICAP).
Calculations of final results on computer program.

Sediments - Mercury

SAMPLE PREPARATION/ANALYTICAL PROCEDURES

SCOPE AND APPLICATION

This method is applicable to the determination of mercury in marine sediments, fish tissues, shellfish, crustaceans and other fresh water and marine biota. The detection limit is 0.07 ug/g dry concentration or 0.013 ug/g wet concentration based on a sample size of 0.15 g dry and, 0.75 g wet weight, respectively.

SAMPLE CONDITION

The sample should be preserved (Code 231) and prepared (Codes 236, 238) (attached). Approximately 3 to 5 g. are required to analyze the sample in duplicate.

METHOD PRINCIPLE

The dried, sieved sample is digested with 4 + 1 sulfuric acid, and 50% H_2O_2. This oxidation will decompose inorganic mercury compounds (sulfides included) and organo-mercury complexes. Potassium permanganate is used as an auxillary oxidant. After oxidation the mercury is reduced by stannous chloride and hydrazine sulfate to elemental mercury and determined as described for mercury in water.

INTERFERENCES

1. Without a drying tube, water can condense on the absorption cell windows. If the apparatus, reagents and samples are at room temperature, and the cell is constantly purged between samples, condensation does not occur.

2. Low mercury recoveries usually indicate an incomplete digestion, most often as a result of using too much sample. Reduce the sample size and analyze again.

APPARATUS

1. Reaction tubes
   These tubes are 100-ml, Pyrex brand, "Student" graduated cylinders without the plastic base and truncated at the 100 ml mark.
2. Hot block and hot plate.
3. Flameless system.
4. Atomic absorption spectrophotometer capable of simultaneous background correction (Jarell Ash 810).

REAGENTS

All the reagents used are of analytical reagent grade. Deionized water is used throughout reagent preparation.

1. Sulfuric acid solution, 4+1: Four parts of concentrated H_2SO_4 are added to one part of water. Cool before use.
2. Hydrogen peroxide, 50% V/V: This reagent is tested for the presence of mercury in the following manner. To 4 ml of H_2SO_2 add 45 ml of water, cover and leave overnight. Add ten ml 4+1 H_2SO_4 and 1 ml 5% w/V $KMnO_4$. Prepare a similar blank with water instead of 50% H_2O_2. Both blanks are then analyzed in the usual manner. At twice the peroxide concentration used in the digestion, no detectable difference between the blanks has been found.
3. Potassium permanganate, 0.1% w/V: Dissolve 1 g of $KMnO_4$ in 1 litre of water and refrigerate before use. As the main potential source of mercury contamination, this reagent may contain mercury itself or may extract it from container walls and/or air [4].
4. Reducing solution, 2% w/V hydroxylamine sulfate, 1% w/V hydrazine sulfate, 3% w/V stannous chloride:
   Dissolve 10 g of $(NH_2OH)_2.H_2SO_4$ by stirring in 30 ml of water. Add 5 g of $H_2NNH_2.H_2SO_4$, stir until dissolved. Add 15 g of $SnCl_2.2H_2O$ and dissolve. The entire solution is then diluted to 500 ml with water (Note 4).

REAGENTS (continued)

5. Mercury standards, 0.01 to 0.5 ug: Prepare 0.10, 1.0 and 10.0 ug/ml Hg standards from a 1000 mg/l stock solution. From these standards prepare a working range by pipeting appropriate volumes into the reaction tubes.

CONCENTRATION OF STANDARD (ug/ml)	VOLUME USED (ml)	RESULTING HG WEIGHT (ug)
0	0	0
0.01	0.10	0.01
1.0	0.05	0.05
1.0	0.10	0.10
1.0	0.20	0.20
1.0	0.30	0.30
1.0	0.40	0.40
10.0	0.05	0.05

Using the tube graduations, dilute to 10.0 ml with deionized water. Add 10.0 ml of 4+1, H_2SO_4+H_2O, swirl and cool. Add 40.0 ml of 0.1% w/V $KMnO_4$ forcefully to facilitate mixing. Cover and analyze as with sample procedure.

PROCEDURE

1. Weigh approximately 0.075 g of freeze-dried sample into a 100-ml reaction tube. Prepare a duplicate and record the vial number, tube number and sample weight.
2. Add 10.0 ml of 4+1, H_2SO_4+H_2O solution in a constant stream, cover and leave overnight.
3. Add 4.0 ml of 50% H_2O_2 swirl and place the tube on the hot block.
4. Switch the hotplate to 5 (Corning PC100) and heat the tubes until the solution turns colorless (Note 5) and the bubbling stops (approximately 1-1.25 hours).

PROCEDURE (continued)

5. Remove the tubes from the block, cool them in a cold water bath and add 30.0 ml of cool 0.1% $KMnO_4$. The final volume should be 50.0 ml.
6. Adjust the instrument as per the manufacturer's instructions. Mercury absorbance is measured at 253.7 nm, and background absorbance is measured at 254.7 nm using a tin hollow cathode lamp.
7. Set the argon flow at 40 ml/min (5 on the flow meter) and switch the flow to the gas dispersion tube (Note 6).
8. Place a reaction tube on the apparatus and inject forcefully 5.0 ml of the reducing solution.
9. When the maximum peak height has been obtained, remove the tube and switch the argon flow to purge.
10. Switch the argon flow to the dispersion tube, put on the next tube and repeat the process (Note 7).

NOTES

1. No loss of mercury has been associated with this procedure [5, 6].
2. The use of argon as a sweep gas eliminated potential mercury contamination and increased absorbance by 25% [7].
3. An open flameless system is used rather than a closed system which requries a time consuming summation of absorbance peaks [8] and suffers from reproducibility problems [9].
4. Hydroxylamine sulfate destroys excess permanganate and manganese oxide. Hydrazine sulfate accelerates the reaction of stannous chloride [10].
5. If the tubes are left too long on the hot block, the solution becomes colored slightly, however, the effect on the accuracy of the results is negligible.
6. This flow was determined empirically to obtain maximum absorbance. If the cell and tubing are changed radically, the optimum flow rate must be determined.
7. Tests showed that waiting for a return to baseline between samples was not necessary and rinsing the gas dispersion tube between samples was not necessary as carry-over was not detectable in either case.

CALCULATIONS

1. Draw a standard curve of ug/Hg vs absorbance.

2. Wet/Dry Ratio = $\frac{\text{weight before freeze drying (g)}}{\text{weight after freeze drying (g)}}$

3. ug/g dry weight Hg = $\frac{\text{ug Hg from curve}}{\text{dry weight in tube (g)}}$

4. ug/g wet weight = (ug/g dry weight Hg) (wet/dry ratio)

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Sediments - Trace Metals

PRESERVATION (231) - PREPARATION (236, 238)

SCOPE AND APPLICATION

These methods are used to prepare sediments, soils and sludges prior to decomposition and metal determination.

SAMPLE CONDITION

Collect a representative sample (Note 1), drain off excess water, place the sample in a plastic bottle or whirl-pak bag and freeze.

METHOD PRINCIPLE

The sample is freeze dried and sieved using a 100 mesh (.150 mm) stainless steel sieve. The 100 mesh fraction includes the principle "adsorbers" of metals (clays, hydrous oxides and fine quartz) and particles which are small enough to be ingested by benthic biota.

INTERFERENCES

1. Volatilization of metals during freeze drying is possible but has not been conclusively demonstrated. Much depends (to an unknown extent) on the sample composition, metals present and their binding or adsorption characteristics.
2. The sieve must be composed of stainless steel as opposed to brass (Cu contamination) or plastic (mesh opens out and wears quickly).

APPARATUS

1. Freeze drying, apparatus.
2. Stainless steel sieves, 100 mesh.
3. Acid washed plastic vials and bottles.

REAGENTS

1. Deionized water.
2. Hydrochloric Acid, 1 + 10: Add 1 part of concentrated HCl to 10 parts of deionized water.

PROCEDURE

1. Soak all plastic vials, bottles and caps in 1 + 10 HCl for at least 24 hours. Rinse 3 times with deionized water and dry.
2. Set up the freeze dryer as per manufacturer's instructions. Place the bags or bottles containing the samples in the freeze dryer. Open the bag or bottle to allow the water to escape.
3. Dry the samples for 48 hours or more until dry.
4. Sieve each sample using the 100 mesh sieve and bottom pan.
5. Place the sieved portion in a clean plastic vial.
6. Clean the sieve with a brush and/or a dry cloth.

NOTES

1. The amount of sample required to be representative is dependent on the sample location. The amount of sample required for metal determination is approximately 2 g dry weight. The analysis is performed on a 100 mesh fraction. Therefore, samples composed mainly of course material necessitate a greater sample size to obtain enough 100 mesh fines for analysis.

CALCULATIONS

There are no calculations but the following data is recorded:

1. Sample number.
2. Vial number.

APPENDIX IVA

TRACE METAL ANALYTICAL PROCEDURES IN SEDIMENTS

(since 1982)

APPENDIX IVA TRACE METAL ANALYTICAL PROCEDURES IN SEDIMENT (since 1982)

SEDIMENT PREPARATION/ANALYTICAL PROCEDURES

1. Transfer sample material to labeled Kraft soil sample envelopes, dry samples at 60 deg. C.

2. When samples are dry, disaggregate the sample material by rapping the sample bag with a rubber mallet. Occasionally, the sample bag may split, this usually occurs when the samples are marine sediments or if the bags are hit too hard. If particle sizing has been requested, split the sample material on a riffle - a normal split is 1/4 for metals and 3/4 for particle sizing. Ensure that the sample splits are done in a manner that minimises biasing of the subsamples. If the particle sizing required is for only the +/- 100 mesh (0.150 mm) fractions sample splitting is not required.

3. Sieve samples through a 100 mesh stainless steel screen, store the fine fraction in a labeled vial, retain the coarse fraction in the Kraft sample bag. Label the vial body with the sample number, eg. "5673-12", label vial caps with sample series only, eg. "5473". If a particle sizing request is for only the +/- 100 mesh (0.150 mm), weigh the coarse and fine fractions and store them in separate vials. Ensure that the screens are brushed clean thoroughly between samples - occasionally the screens should be cleaned in an ultrasonic bath to remove material trapped in the wire mesh. Special care must be taken when handling non-routine type samples to prevent cross contamination between samples - eg. concentrates, salt sediments, sewage sludges, etc.

4. Weigh 0.30 to 0.32 g of sieved sample into calibrated 50 ml test tubes. Replicate samples, reference materials, and reagent blanks must be included with every set of samples. Normally one reference material and one blank should be run with every set of 30 or less samples, the number of replicates should be at least the square root of the number of samples in a given lot. Use computer program "SEDWT" to set up a weight file and take weights directly from the balance. Please not the following conventions:

    a) Tube numbers consist of one letter followed by a number eg. "X137"
    b) The prefix letter "A" is reserved for reference materials
    c) Reagent blanks use the tube number "AØ" (not "AO"!)
    d) Weight file names should be of the form "LXXXXXX", where "L" is the prefix letter of the tube number "XXXXX" may be any alphanumeric characters, normally this is the sample number of the first sample in the weight file.
    e) Assign prefix letters in alphabetical order, avoid the letters "I" and "O" - they are easily confused with the numbers "1" and "Ø".

5. Add 4.5 ml conc. HNO3, 1.5 ml conc. HCl, swirl solution vigorously, allow to react for about ten minutes, then add 15 ml deionized water. Reagents should be dispensed with automatic pipettors, use only "BAKER - Instra-Analyzed (for trace metal analysis)" acids. Wear eye protection when handling acids and sample digest solutions.

6. Place test tubes into pre-heated block and heat for three hours. Sample solutions should boil gently during the digestion period - exercise care with very fine grained samples, they are likely to cause bumping problems.

7. Remove test tubes and allow to cool before diluting sample solutions to 50 ml. Cap test tubes and mix well, allow sample solutions to settle out overnight. Carefully decant sample solutions into 30 ml acid washed poly bottles, ensure that particulate material is not transfered to the sample bottles.

8. Label the body of each bottle with the tube number, eg. "G73"; label the bottle cap with the sample lot number, eg. "1073". Place the bottles containing sample solutions, reference materials, and blanks in an orderly fashion in appropriate bottle trays along with hardcopy of weight file(s) and analysis request sheets. Place bottle trays in the proper area for ICAP sediment samples.

9. Analyse sample solutions by ICAP. Use computer program "SED" to calculate final results.

Mercury in Sediments

A portion of the liquid from the sediment digestion is used for Hg analysis on the Pharmacia mercury monitor, model 1205. The mercury compounds are reduced to elemental Hg with hydroxylamine sulfate and stannous chloride. The mercury vapour produced is swept from the solution with argon and passes through an absorption cell where the absorption is measured at 254 mm.

APPENDIX V

TRACE METAL ANALYTICAL PROCEDURES IN TISSUES

(Revised December 1983)

A. General Sample Preparation
B. Trace Metal Procedures
C. Mercury Procedures

A. GENERAL SAMPLE PREPARATION

1. Label and weigh a sufficient supplyof clean plastic vials. Use computer program BIOWT to set up a weight file (or to add to an existing file) and use the following conventions:

   a) Vials are identified by a "vial number" - the vial number consists of a letter prefix and a number suffix eg.: "G23". The prefix letter "A" is reserved for reference materials and should not be used for samples.

   b) Biota weight file names should consist of a single letter prefix followed by a series of numbers and/or letters, to a maximum of six characters eg. "R1015A". The first letter in the file name should be the same as the prefix letter used for all vial numbers used in that file. The file name "SRM" is reserved for standard reference materials and all vials in this file should have "A" as their prefix letter.

   c) The maximum number of entries in a weight file is 199, try to have 100-150 entries for maximum efficiency and a minimum number of active files.

   d) Assign prefix letters in alphabetical order, start with "B" in the beginning of the year. Some ongoing projects may warrant assigning a single letter for all samples in that project.

2. Homogenize wet tissue samples in a stainless steel blender (if samples are small enough to fit into vial, this step may be omitted). Fill a labeled vial approximately 3/4 full with tissue homogenate. Rinse the blender well with deionized water between samples.

3. Weigh vial + wet sample, use computer program BIOWT and follow sample numbering conventions when entering sample numbers.

4. Cover sample vials with a "Kimwipe", securing it with a rubber band, place samples in freezer and freeze solid. Exercise care when covering samples - rubber bands contain significant levels of zinc and cadmium.

5. Place frozen samples into freeze drier, allow at least 24 hours to dry - excessively wet samples and a "loaded" freeze drier may extend drying time to two or three days. Try to run heavy loads over the weekend if possible.

6. Weigh vial + dry sample, use computer program BIOWT.

7. Pulverize dry sample in a coffee grinder or Wiley mill. Clean coffee grinder well between samples by blowing out with compressed air. Excessively oily samples may coat the grinder, this deposit may be removed by grinding one or two loads of rice, cleaning grinder with a paper towel and then blowing out with compressed air. Very small samples may be pulverised by using a glass rod or stainless steel spatula to grind sample material in the vial.

B. TRACE METAL PROCEDURES

1. Into a marked petri dish weigh approximately 0.5 g. of freeze dried sample, use computer program BIOWT and ensure that the petri dish has been tared properly before adding sample material. To weigh replicate samples, prefix the dish number with the letter "R" eg. enter "R369" for dish # 369; program BIOWT will "insert" this "extra" dish into the weight file.

   All dishes must be covered with watchglasses immediately after sample material has been weighed to reduce contamination.

   For any given lot of samples, the number of replicate samples run for that lot should be at least the square root of the number of samples in that lot; eg. for 16 samples do 4 replicates and for 19 samples do 5 replicates. Each group of samples should have at least two reagent blanks and at least two reference material samples run with that group of samples. Reagent blanks do not need to be entered in a weight file; the vial # - dish # combination of "A0-0" is reserved for reagent blanks and a dummy sample weight of 0.5 g. is used. All reference materials should be entered in the "SRM" weight file and their vial numbers have prefix letter "A", dummy entries for vial, vial + wet sample, vial + dry sample weights of "+ 9", "+10", "+10" must be entered in the SRM weight file before dish sample weights are entered.

2. Load coverless dishes into plasma asher and ash overnight - see asher operating instructions. Each asher load should contain one reagent blank and one reference material run along with the samples.

3. Remove samples from asher, cover with watchglasses, digest as follows:

   a) Add 2.25 mls. nitric acid (HNO_3) - warm on hotplate, if sample readily dissolves then take down to near dryness, cool, then add 2.25 mls. nitric acid (HNO_3). Excessively oily or chunky samples may require further treatment with HNO_3.

   b) Allow dishes to cool, then add 0.75 mls. HCl, warm on hotplate to dissolve material. Occasionally, a sandy residue may remain - this residue is usually sand and is normally found with shellfish. Most tissue samples should produce clear, colourless sample solutions.

   c) Allow dishes to cool, transfer contents quantitatively to labeled centrifuge tubes, make up to 25.0 mls. with DI water, mix well. Enter sample solution volumes in weight file, use computer program BIOTA.

4. Transfer sample solutions to 30 ml. acid washed bottles. Label bottle with "vial# - dish #" - eg. "G37 - 432"; mark bottle cap with sample lot number - eg. for sample # "831234 - 567" use "1234". Place bottles containing sample solutions, reference materials, and reagent blanks in an orderly fashion in appropriate bottle trays along with hardcopy of weight file(s) and analysis request sheets. Place bottle trays in proper areas for ICAP biota samples.

5. Analyse sample solutions by ICAP, use computer program "Biota" to calculate final results.

C. MERCURY PROCEDURES

APPARATUS

1. Reaction tubes - These are 100 ml. pyrex brand, "student" graduated cylinders without the plastic base.
2. Hot block and hot plate.
3. Pharmacia Mercury Monitor - model 1205.

REAGENTS

All the reagents are analytical grade. Deionized water is used throughout reagent preparation.

1. Sulphuric acid solution, 4 + 1. Four parts concentrated sulphuric acid are added to one part water. Cool.
2. Hydrogen peroxide, 50% V/V. This reagent is tested for the presence of mercury in the following manner. To 4 mls. of sulphuric acid add 45 mls. water, cover and leave overnight. Add 10 mls. 4 + 1 sulphuric acid. Add 4 mls. of hydrogen peroxide. Prepare a similar blank with water instead of hydrogen peroxide. Both blanks are then analysed in the usual manner. There should be no detectable differences.
3. Wash water. Add 160 mls. concentrated sulphuric acid and 20 mls. concentrated nitric acid to some water. Volumize to 1 liter.
4. Reducing solution. Add 50 mls. concentrated sulphuric acid to 450 mls. water. Add 15 gms. sodium chloride and mix. Add 15 gms. hydroxylamine sulphate and mix. Add 25 gms. stannous chloride and mix. This reagent will keep.
5. Mercury standards, 0.1 ug/l to 7.5 ug/l.

PROCEDURE

1. Weigh approximately 0.1 gms. of freeze dried sample into a 100 ml. reaction tube. Duplicates should be done. 0.1 gms. +/_ 0.005 gms. should be used. A reference material should also be analysed.

PROCEDURE (continued)

2. Add 10.0 mls. of 4 + 1, sulphuric acid in a constant stream, to cover the sample. Cover and leave overnight.
3. Add 3.0 mls. hydrogen peroxide and place the tube in the cool hotblock.
4. Switch the hotplate to 4.5 (Corning PC100) and heat until the solution is colorless (note 2) and the bubbling has stopped. (Approximately 1-1.5 hours).
5. Remove from heat and add 1 mls. nitric acid.
6. Volumize to 50 mls. with water, mix well and cool
7. Analyse on the mercury monitor.

CALCULATIONS

1. Use #GFAA to enter the peak heights.
2. Combine with BIOWT file that is created for mercury during sample preparation.

NOTES

1. No loss of mercury has been associated with this procedure. (5, 6).
2. If the tubes are left too long on the hot block, the solution becomes colored slightly, this does not affect the results.